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SUGARBEET RESEARCH

1967 REPORT

Compiled by Sugarbeet Investigations

CROPS RESEARCH DIVISION
AGRICULTURAL RESEARCH SERVICE
UNITED STATES DEPARTMENT OF AGRICULTURE

UNITED STATES DEPARTMENT OF AGRICULTURE
AGRICULTURAL RESEARCH SERVICE
Crops Research Division
Beltsville, Maryland

SUGARBEET RESEARCH

1967 REPORT^{1/}

Compiled by Sugarbeet Investigations

^{1/} This progress report of cooperative investigations contains data, the interpretation of which may be modified with additional experimentation. Therefore, publication, display, or distribution of any data or statements herein should not be made without prior written approval of the Crops Research Division, ARS, U.S. Department of Agriculture, and the Cooperating Agency or agencies concerned.

CR-4-68

F O R E W O R D

SUGARBEET RESEARCH is an annual compilation of the research accomplishments by staff members of Sugarbeet Investigations and Cooperators. The data in most of the progress reports are later used in the preparation of comprehensive manuscripts for technical publications.

The reports present results of investigations strengthened by contributions received under Cooperative Agreements between Crops Research Division, Agricultural Research Service, U.S. Department of Agriculture, and the Beet Sugar Development Foundation; the Farmers and Manufacturers Beet Sugar Association; and Union Sugar Division, Consolidated Foods Corporation.

At Salinas, California, research is further strengthened through contributions from the California Beet Growers Association, Ltd.

TRADE NAMES occur in these progress reports solely to provide specific information and do not signify endorsement by the U.S. Department of Agriculture.

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HIGHLIGHTS OF ACCOMPLISHMENTS^{1/}

US H9A and US H9B: The official release of US H9A and US H9B is an outstanding accomplishment of 1967. Results of extensive field tests, which are presented in Part II, document the excellent performance of these related hybrids. They are characterized by monogerm seed, tolerance to virus yellows and to curly top, good in bolting resistance, excellent in quality of juice, and more productive than US H7, the standard of comparison. The monogerm parental lines of the male sterile F₁, which is used as the seed parent in commercial seed production, are moderately resistant to curly top. The multigerm pollen parent, which was derived from US 75, is tolerant to virus yellows. Thus the new hybrids, US H9A and US H9B, are endowed by their parents with biological protection against two important diseases of California and other Western States.

As an average US H9A and US H9B showed a gain of about 25% in sugar yield over US H7. Under moderate virus yellows exposure the new hybrids when compared with US 75 showed a gain of 66% in sugar per acre and better quality. Approximately 15 years ago US 75 was the standard variety grown in California and US H7, a monogerm hybrid, has been widely used in the same area.

Yellows Resistance continues to show improvement through the application of a breeding method that involves the inoculation of plants and the appraisal of reduction in root yield caused by the viruses. An essential feature of the method is maintenance of comparison plots of non-inoculated plants which remain largely free of the disease until harvest. In a group of open pollinated lines the sugar yield reductions caused by the viruses ranged from 21.0% for 613A to 42.7% for US 75. Line 613A is the 7th cycle of selection from US 75. Two selections based on amino acid ratios were not significantly different in resistance from US 75. Among several hybrids in which one or more parental lines had been selected for yellows resistance the entries ranged from 23.3% to 36.0% reduction due to the disease. US H7 which has no resistant parental component, suffered a loss of 43.1%. It was concluded from the study of performances of various hybrids of diverse parental background that resistance to the yellows virus is inherited in an additive manner. Resistance to beet yellows virus and beet western yellows virus in the lines tested seemed to be partially associated.

^{1/} Prepared by Dewey Stewart.

Downy Mildew has been reduced to a disease of minor importance in California through the use of varieties moderately resistant to the pathogen. Although the level of resistance has not been very high, the biological protection has given adequate control. In the event more virulent strains of the pathogen or weather conditions favor disease development, inbred lines that are more resistant are available if the need should arise.

Resistance to the Cyst Nematode and to Curly Top Through Interspecific Hybridizations: Three generations of hybrids between sugarbeet and Patellares species were tested for resistance to the cyst nematode, Heterodera schachtii. In all 3,080 plants were tested consisting of: 2,537 b_1 hybrids, 462 b_2 hybrids and 81 b_3 hybrids. Each of the b_3 plants were derived from b_2 plants which carried a 19th chromosome responsible for nematode resistance. Among the progeny of these hybrids, two plants were immune or essentially so. These plants developed fleshy roots and have 18 chromosomes as in diploid sugarbeet. In populations of b_1 hybrids, 54 plants developed tumors on roots or leaves, 7 plants were annual, 3 did not develop fleshy root and some were inviable as in F_1 hybrids.

Beta Corolliflora is highly resistant or immune to the curly top virus. F_1 hybrids of $4n$ sugarbeet and B. Corolliflora were pollinated by diploid sugarbeet. All b_1 plants were triploid or aneuploid. Four hundred b_1 plants were inoculated with a virulent strain of the curly top virus. Twenty-nine were selected as resistant. These were brought to flower and pollinated by diploid sugarbeet. In all 257 b_2 plants were obtained. Following inoculation some plants showed no symptoms of the disease. In all 19 plants, apparently immune to the virus, are being continued in the breeding program. Most of these have 22 chromosomes which probably include 4 chromosomes of B. Corolliflora.

Seed Viability: Cytogenetic and embryogenic studies on viability in diploid, triploid, and tetraploid seeds resulted in recommendation for quality improvement. The sugarbeet has not been selected for viability of seed because the multigerm fruits were not amenable to such endeavors. Monogerm sugarbeet now offers an opportunity to improve the genetic background of this important characteristic. Improved field practices in sugarbeet seed production can supplement the genetic influence. In the production of triploid seed the female parent should be monogerm because cytogenetic principles indicate reduced aneuploidy. For the same reason the female parent should be tetraploid. Basic improvement in breeding of triploid and tetraploid varieties, besides improvement of fertility of male sterile lines, will consist of producing tetraploid

populations with lower numbers of multivalent associations and lower grades of aneuploidy.

The concluding report of several years of study on the cytogenetic and embryogenic factors determining viability and quality in triploid and tetraploid seed is given on pages 98-122.

Breeding for Nematode Resistance by selecting among cultivars of sugarbeet based on the number of emerging cysts on roots of seedlings did not show sufficient genotypic variation to warrant use of the method. If there were genetic differences among the lines under test they were small and environmental variation masked their effects. It is known that temperature and moisture influence cyst formation and more accurate control of these factors would be required than was available. Field tests conducted in nematode infested soil indicated the highest beet yields for those entries that had previously been selected for resistance. Only one entry demonstrated significant wilt resistance and it was an *Aphanomyces* resistant selection. A selection scheme based on the concentration of aspartic acid, glutamic acid, and glutamine in infected fibrous roots of nematode infested plants appears to have more promise than cyst counts.

Nematodes of the ectoparasitic type have been implicated as the causal agents of rubber root and wilt of sugarbeet in Arizona. See photos on pages 150 and 151.

Genetic Studies: Recently found pollen-restorer effect in sugarbeet presents the possibility of producing commercial four-way hybrids by using only cytoplasmic male sterility. The scheme is (CMS X Type-0) X (CMS X R_f pollinator). Extensive tests with proper hybrids indicate there may be a heterotic effect on yield and quality in sugarbeet due to interaction of male cytoplasm and R_f genes.

Linkage tests showed the a₁ gene responsible for Mendelian male sterility was independently inherited from the several other genes involved in the study. Dwarf, d and lutescens, lu₂ were inherited independently of the Y-R-B group. Russet root, ru and lu₂ were not associated with monogerm seed, m. Linkage of red color, R and trout leaf, Tr and lack of association of monogerm, m as reported by others was confirmed.

A study of genetic variances and correlations in search for helpful associations among divalent metals of the leaves, non-sucrose components of the juice, and beet yield and quality revealed only consistent genetic correlations for root weight and recoverable sugar and calcium versus magnesium.

AWARDS OF ACCOMPLISHMENTS

Sugarbeet Research, 1967 Report, provides an opportunity to reflect and to record some outstanding accomplishments of Sugarbeet Investigations and cooperators over the past few decades. On page 5 is a photo of Superior Service Award, Group Achievement of Sugarbeet Investigations, in recognition of its development of basic breeding lines of monogerm sugarbeet. The Award was presented on May 8, 1968, by The Honorable Orville L. Freeman, Secretary of Agriculture, at the 22nd Annual Awards Ceremony. The entire scientific staff, plus one who was retired and one who was deceased, were recognized in the Award. The changeover from multigerm to monogerm varieties is indicated by statistics of sugarbeet seed production (page 21).

On page 6 is a photo of Superior Service Award, Curly Top Project, Sugarbeet Investigations, presented by The Honorable Clinton P. Anderson, Secretary of Agriculture, at the 1st Annual Award Ceremony of June 1947. The initial accomplishment was the release in 1932 of US 1, the first American commercial variety of sugarbeet of distinctive characteristics. By 1947, progressive varietal improvement had brought about US 22/4, a variety providing adequate biological control of curly top, one of the most devastating plant diseases of our Western States.

Thus Sugarbeet Investigations, a crop oriented group of scientists, has been twice awarded for superior service by the U.S. Department of Agriculture during the first 22 years of Annual Awards to its employees. It is also worthy of note that during this period 6 individual scientists of Sugarbeet Investigations received Superior Service Awards. These Awards, to the group, to the unit, and to individuals, document excellence in performance and outstanding achievements.

In modern times research created the sugarbeet and fashioned it as a sugar plant suitable for temperate climates of the world. Although a successful crop in Europe, this immigrant plant in America experienced greater hardship and contended with more aggressive enemies than did the pioneers who sponsored its introduction. Without the protection and resistance provided through research, the sugarbeet would never have survived in the New World; nor could it have conformed to the demands of mechanized agriculture; nor would it now enjoy the benefits of enhanced vigor made possible through the development of cytoplasmic male sterility as a device for the production of hybrid seed.

Sugarbeet Investigations, with the assistance of many devoted cooperators in the employment of sugar companies and with generous financial support provided through the Beet Sugar Development Foundation as exemplified by this Report, has largely been responsible for the successful Americanization of the sugarbeet, the source plant of almost a third of our national requirement of sugar -- a pleasing and energizing food.



UNITED STATES DEPARTMENT OF AGRICULTURE
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SUGARBEET INVESTIGATIONS

AGRICULTURAL RESEARCH SERVICE
BELTSVILLE, MARYLAND

FOR DEVELOPMENT OF BASIC PARENTAL LINES AND HYBRID VARIETIES OF
MONOGERM SUGARBEET THAT ELIMINATED THE NEED FOR HAND SINGLING
AND PERMITS COMPLETE MECHANIZATION OF PRODUCTION PRACTICES.

MAY, 1968

ORVILLE L. FREEMAN
SECRETARY OF AGRICULTURE



United States Department of Agriculture

Award for Superior Service

*P I T A E - Division of Sugar Plant Investigations
Sugar Beet Curly Top Project*

*is hereby given Official Commendation
for Superior Service*

Citation:

FOR SAVING THE SUGAR BEET INDUSTRY IN THE INTERMOUNTAIN
WEST THROUGH FINDING RESISTANCE TO CURLY TOP AND BREEDING
AND INTRODUCING SUGAR BEET VARIETIES RESISTANT TO THE DISEASE

Clarence P. Anderson
Secretary of Agriculture

AWARDED 1947

P A R T I

NEW BREEDING MATERIAL

Items Proposed for Seed Increase

Utilization and Distribution of Items

PRODUCTION OF MONOGERM SEED IN U.S.A.

NEW DEVELOPMENTS IN BREEDING RESEARCH

Proposals for Seed Production and Utilization May 26, 1967

Breeder seed and inbred lines that have been developed in the breeding research conducted by the staff of Sugarbeet Investigations are proposed for seed production through the Beet Sugar Development Foundation. Seed not needed for planting overwintering plots will be furnished on request to company members of the Foundation for utilization in their breeding programs. Brief descriptions, current designations, and estimates of seed available August 1 are given for the items.

These items of breedseed have been developed by the staff of Sugarbeet Investigations through research conducted under Cooperation Agreements with:

California Agricultural Experiment Station
Colorado Agricultural Experiment Station
Michigan Agricultural Experiment Station
Utah Agricultural Experiment Station
Beet Sugar Development Foundation
Farmers & Manufacturers Beet Sugar Association
Union Sugar Division, Consolidated Foods Corporation

Items Proposed for Seed Increase and Utilization

I. U.S. Agricultural Research Station, Salinas, California.

A. Developments in breeding research by J. S. McFarlane, I. O. Skoyen, B. L. Hammond, and R. T. Lewellen:

Item 1. C613 Multigerm 1 pound

A yellows-resistant selection from US 75. Seven successive selections were made on the basis of root size and freedom from yellowing. This selection represents a further improvement in yellows resistance over C330 and C413 which were made available in 1963 and 1965, respectively. Hybrids utilizing C613 as pollen parent are included in the 1967 tests.

Suggested utilization: Use as a breeding line. C613 may be increased for use as pollen parent, but waiting until results of hybrid tests are available is recommended.

Item 2. C630T Multigerm 100 grams

Increase of a tetraploid derived from the yellows-resistant C330 (Item 5, 1963); a selection from US 75. Tests with triploid hybrids utilizing C630T as the pollen parent are underway.

Suggested utilization: Use as breeding line and as pollen parent in test hybrids.

Item 3. C786T Multigerm 100 grams

Increase of tetraploid derived from a bolting resistant, high sucrose selection from US 22.

Suggested utilization: Use as a breeding line and as pollen parent in test hybrids.

Item 4. C7601 Monogerm 100 grams

Increase of S_3 (871 x 0561-16-1). Greenhouse tests have shown this inbred to be highly resistant to curly top. Good bolting resistance.

Suggested utilization: Source of curly top resistance.

Item 5. C7760 Multigerm 100 grams

An inbred line derived from a cross between a yellows-resistant selection from US 75 and a yellows-resistant self-fertile line. C7760 has shown excellent vigor and very good yellows resistance. It has good resistance to bolting and curly top.

Suggested utilization: Source of yellows resistance.

B. Development in breeding and genetic research conducted by
V. F. and Helen Savitsky:

Item 6. S-127 Monogerm 50 grams

A tetraploid, monogerm inbred that is resistant to curly top.

Suggested utilization: Use in breeding programs and as tetraploid pollinator. Seed available on request.

Item 7. S-235 Multigerm 100 grams

A tetraploid, self-sterile multigerm line that is excellent in curly top resistance as a result of selection at Logan, Utah.

Suggested utilization: Use in breeding programs and as tetraploid pollinator. Seed available on request.

Item 8. S-240 Multigerm 100 grams

A tetraploid, self-sterile multigerm line that is excellent in curly top resistance as a result of selection at Logan, Utah.

Suggested utilization: Use in breeding programs and as tetraploid pollinator. Seed available on request.

Item 9. S-242 Multigerm 100 grams

A tetraploid, self-sterile multigerm line that is excellent in curly top resistance as a result of selection at Logan, Utah.

Suggested utilization: Use in breeding programs and as tetraploid pollinator. Seed available on request.

Item 10. S-258 Multigerm 100 grams

A tetraploid, self-sterile multigerm line that is excellent in curly top resistance as a result of selection at Logan, Utah.

Suggested utilization: Use in breeding programs and as tetraploid pollinator. Seed available on request.

Item 11. S-560 Monogerm 100 grams

A tetraploid, self-sterile monogerm line that is excellent in curly top resistance as a result of selection at Logan, Utah.

Suggested utilization: Use in breeding programs and as tetraploid pollinator. Seed available on request.

Item 12. S-571 Monogerm 100 grams

A tetraploid, self-sterile monogerm line that is excellent in curly top resistance as a result of selection at Logan, Utah.

Suggested utilization: Use in breeding programs and as tetraploid pollinator. Seed available on request.

Item 13. S-572 Monogerm 100 grams

A tetraploid, self-sterile monogerm line that is excellent in curly top resistance as a result of selection at Logan, Utah.

Suggested utilization: Use in breeding programs and as tetraploid pollinator. Seed available on request.

Item 14. S-582 Monogerm 100 grams

A tetraploid, self-sterile monogerm line that is excellent in curly top resistance as a result of selection at Logan, Utah.

Suggested utilization: Use in breeding programs and as tetraploid pollinator. Seed available on request.

Item 15. S-610 Multigerm 100 grams

A tetraploid, self-sterile multigerm line derived from hybridizations of curly top resistant lines ($4n$) and tetraploid Janasz which is excellent in sucrose percentage.

Suggested utilization: Use in breeding programs and as tetraploid pollinator. Seed available on request.

Item 16. S-615 Multigerm 100 grams

A tetraploid, self-sterile multigerm line derived from hybridizations of curly top resistant lines ($4n$) and tetraploid Janasz which is excellent in sucrose percentage.

Suggested utilization: Use in breeding programs and as tetraploid pollinator. Seed available on request.

C. Developments in breeding and genetic research conducted by V. F. and Helen Savitsky. Evaluations for leaf spot resistance in 1965 and seed productions in 1966 by J. O. Gaskill, Fort Collins, Colorado.

Item 17. SP 661017-0 Multigerm Germ. 41 s/g* 2 pounds

An increase of a tetraploid, LSR-CTR, self-sterile line, S-65-6, with high-sucrose Janasz "blood," developed by V. F. and Helen Savitsky. Seed increase made at Fort Collins, Colorado.

Item 18. SP 661018-0 Multigerm Germ. 35 s/g* 2 pounds

An increase of a tetraploid, LSR-CTR, self-sterile line, S-65-7, with high-sucrose Janasz "blood," developed by V. F. and Helen Savitsky. Seed increase made at Fort Collins, Colorado.

Item 19. SP 661019-0 Multigerm Germ. 36 s/g* 2 pounds

An increase of a tetraploid, LSR-CTR, self-sterile line, S-65-8, with high-sucrose Janasz "blood," developed by V. F. and Helen Savitsky. Seed increase made at Fort Collins, Colorado.

Item 20. SP 661020-0 Multigerm Germ. 44 s/g* 2 pounds

An increase of a tetraploid, LSR-CTR, self-sterile line, S-65-11, with high-sucrose Janasz "blood," developed by V. F. and Helen Savitsky. Seed increase made at Fort Collins, Colorado.

Item 21. SP 661021-0 Multigerm Germ. 28 s/g* 2 pounds

An increase of a tetraploid, LSR-CTR, self-sterile line, S-65-12, with high-sucrose Janasz "blood," developed by V. F. and Helen Savitsky. Seed increase made at Fort Collins, Colorado.

Item 22. SP 661022-0 Multigerm Germ. 33 s/g* 2 pounds

An increase of a tetraploid, LSR-CTR, self-sterile line, S-65-14, with high-sucrose Janasz "blood," developed by V. F. and Helen Savitsky. Seed increase made at Fort Collins, Colorado.

Item 23. SP 661023-0 Multigerm Germ. 34 s/g* 2 pounds

An increase of a tetraploid, LSR-CTR, self-sterile line, S-65-5, derived from US 401 x CTR by V. F. and Helen Savitsky. Seed increase made at Fort Collins, Colorado.

Item 24. SP 661024-0 Multigerm Germ. 41 s/g* 2 pounds

An increase of a tetraploid, LSR-CTR, self-sterile line, S-65-26 (S-63-17), developed by V. F. and Helen Savitsky. Seed increase made at Fort Collins, Colorado.

Item 25. SP 661025-0 Multigerm Germ. 18 s/g* 1 pound

An increase of a tetraploid, LSR-CTR, self-sterile line, S-65-27, developed by V. F. and Helen Savitsky. Seed increase made at Fort Collins, Colorado.

Item 26. SP 661026-0 Multigerm Germ. 30 s/g* 2 pounds

An increase of a tetraploid, LSR-CTR, self-sterile line, S-65-30, developed by V. F. and Helen Savitsky. Seed increase made at Fort Collins.

* s/g = seedlings per gram of seed in steamed soil.
Seed is on hand at Fort Collins and could be distributed at any time.

II. Sugarbeet Investigations, Fort Collins, Colorado.

Developments in breeding research by J. O. Gaskill:

Item 27. FC 701 Multigerm 3 pounds

Rhizoctonia resistant; derived from GW 674-56C by means of 4 cycles of mass selection under artificial Rhizoctonia exposure; essentially RR; presumably self sterile; narrow base; probably rather low in root yield.

Suggested utilization: Increase in order to make a large quantity of seed available for Rhizoctonia-resistance comparisons in many areas.

Item 28. FC 702 Multigerm 3 pounds

Rhizoctonia resistant; derived from C817 by means of 4 cycles of mass selection under artificial Rhizoctonia exposure; about 50% rr; presumably self sterile; narrow base; low in root yield. C817 is a G.W.S. Co. increase of LeRoy Powers' "Sel. A54-1 Synthetic," a product of selection from GW 359-52R without exposure to Rhizoctonia.

Suggested utilization: Same as for FC 701.

III. Plant Industry Station, Beltsville, Maryland.

Developments in breeding research by G. E. Coe:

Item 29. SP 67503-01 Monogerm 1 pound

Seed of the male-sterile phase of SP 67503, a line with good leaf spot resistance and moderate black root resistance. The roots are large for an inbred. The pollinator phase (SP 67503-0) is being rechecked for trueness to type O performance. Seed increase of both phases of the line will be made at Plant Industry Station 1967/1968.

Suggested utilization: Use current supply of seed of SP 67503-01 (male-sterile phase of the line) for the production of experimental hybrids.

Item 30. SP 67519-01 Monogerm 1 pound

Seed of the male-sterile phase of SP 67519, a line with good leaf spot resistance and moderate black root resistance. The pollinator phase (SP 67519-0) is being rechecked for true-ness to type O performance. Seed increase of both phases of the line will be made at Plant Industry Station 1967/1968.

Suggested utilization: Use current supply of seed of SP 67519-01 (male-sterile phase of the line) for the production of experimental hybrids.

Item 31. SP 67547-01 Monogerm 1 pound

Seed of the male-sterile phase of SP 67547, a line with good leaf spot resistance and moderate black root resistance. The pollinator phase (SP 67547-0) is being rechecked for trueness to type O performance. Seed increase of both phases of the line will be made at Plant Industry Station 1967/1968.

Suggested utilization: Use current supply of seed of SP 67547-01 (male-sterile phase of the line) for the production of experimental hybrids.

Item 32. SP 67550-01 Monogerm 1 pound

Seed of the male-sterile phase of SP 67550, a monogerm line with good leaf spot resistance and moderate black root resistance. The line is characterized by slightly narrow leaves. The pollinator phase (SP 67550-0) is being rechecked for trueness to type O performance. Seed increase of both phases of the line will be made at Plant Industry Station 1967/1968.

Suggested utilization: Use current seed supply of SP 67550-01 (male-sterile phase of the line) for the production of experimental hybrids.

Item 33. SP 67552-01 Monogerm 1 pound

Seed of the male-sterile phase of SP 67552, a monogerm line with good leaf spot resistance and moderate black root resistance. The line is characterized by small, well-shaped crowns. The pollinator phase (SP 67552-0) is being rechecked for trueness to type O performance. Seed increase of both phases of the line will be made at Plant Industry Station 1967/1968.

Suggested utilization: Use current seed supply of SP 67552-01 (male-sterile phase of the line) for the production of experimental hybrids.

Item 34. SP 67555-01 Monogerm 1 pound

Seed of the male-sterile phase of SP 67555, a monogerm line with good leaf spot resistance and moderate black root resistance. The pollinator phase (SP 67555-0) is being rechecked for trueness to type O performance. Seed increase of both phases of the line will be made at Plant Industry Station 1967/1968.

Suggested utilization: Use current seed supply of SP 67555-01 (male-sterile phase of the line) for the production of experimental hybrids.

Note on Items 17 through 26

Items 17-26 have come from curly top resistant material. The CT reading given to Mr. Gaskill by Dr. Helen Savitsky is somewhat incomplete but is shown here along with the leaf spot reading. The 10 numbers have been selected by Mr. Gaskill from an original list of 31, based on leaf spot readings.

	<u>CTR</u>	<u>Leaf Spot</u>
Item 17	5	4.0
Item 18	5	3.7
Item 19	3	4.2
Item 20	5	3.5
Item 21	3	4.3
Item 22	?	4.2
Item 23	?	4.0
Item 24	?	3.7
Item 25	3	4.0
Item 26	3	3.8

The leaf spot checks were: Synthetic, 7.7; US 201, 1.0; S-23, 0.5; and US 401, 3.7.

BEET SUGAR DEVELOPMENT FOUNDATION

P. O. BOX 538
FORT COLLINS, COLORADO
80521

UTILIZATION OF USDA SEED RELEASES, 1967

Item numbers and seed numbers are identical with those listed in the release memorandum dated May 26, 1967.

I. U. S. Agricultural Research Station, Salinas, California

A. Developments in breeding research by J. S. McFarlane, I. O. Skoyen, B. L. Hammond and R. T. Lewellen.

Item 1. C613 Multigerm 1 pound

From the available amount, Great Western, Holly and Utah-Idaho each want 10 grams now, American Crystal wants 20 grams now and Spreckels wants 30 grams now. The balance of the seed will be used for an increase by the West Coast Beet Seed Company, the increase to be shared by American Crystal, Holly, Spreckels and Union.

Item 2. C630T Multigerm 100 grams

The available seed will be shared now by Great Western, Holly, Spreckels, Union and Utah-Idaho.

Item 3. C786T Multigerm 100 grams

The amount of seed available will be distributed now to Amalgamated, Great Western, Holly, Spreckels, Union and Utah-Idaho.

Item 4. C7601 Monogerm 100 grams

Same distribution as noted for Item 3.

Item 5. C7760 Multigerm 100 grams

The amount of seed available will be distributed now among the following companies: Amalgamated, American Crystal, Great Western, Holly, Spreckels, Union and Utah-Idaho.

B. Development in breeding and genetic research conducted by V. F. and Helen Savitsky.

Item 6. S-127 Monogerm 50 grams

The amount of seed available will be distributed now among Amalgamated, American Crystal, Great Western, Holly, Spreckels, Union and Utah-Idaho.

Utilization of USDA Seed Releases, 1967
Page 2

Item 7. S-235 Multigerm 100 grams

Same distribution as noted for Item 6.

Item 8. S-240 Multigerm 100 grams

Same distribution as noted for Item 6.

Item 9. S-242 Multigerm 100 grams

Same distribution as noted for Item 6.

Item 10. S-258 Multigerm 100 grams

Same distribution as noted for Item 6.

Item 11. S-560 Monogerm 100 grams

Same distribution as noted for Item 6.

Item 12. S-571 Monogerm 100 grams

Same distribution as noted for Item 6.

Item 13. S-572 Monogerm 100 grams

Same distribution as noted for Item 6.

Item 14. S-582 Monogerm 100 grams

Same distribution as noted for Item 6.

Item 15. S-610 Multigerm 100 grams

Same distribution as noted for Item 6.

Item 16. S-615 Multigerm 100 grams

Same distribution as noted for Item 6.

- C. Developments in breeding and genetic research conducted by V. F. and Helen Savitsky. Evaluations for leaf spot resistance in 1965 and seed productions in 1966 by J. O. Gaskill, Fort Collins, Colorado.

Item 17. SP 661017-0 Multigerm 2 pounds

The amount of seed available will be distributed now among Amalgamated, American Crystal, F & M, Great Western, Holly, Spreckels and Utah-Idaho.

Utilization of USDA Seed Releases, 1967

Page 3

Item 18. SP 661018-0 Multigerm 2 pounds

Same distribution as noted for Item 17.

Item 19. SP 661019-0 Multigerm 2 pounds

Same distribution as noted for Item 17.

Item 20. SP 661020-0 Multigerm 2 pounds

Same distribution as noted for Item 17.

Item 21. SP 661021-0 Multigerm 2 pounds

Same distribution as noted for Item 17.

Item 22. SP 661022-0 Multigerm 2 pounds

Same distribution as noted for Item 17.

Item 23. SP 661023-0 Multigerm 2 pounds

Same distribution as noted for Item 17.

Item 24. SP 661024-0 Multigerm 2 pounds

Same distribution as noted for Item 17.

Item 25. SP 661025-0 Multigerm 1 pound

Same distribution as noted for Item 17.

Item 26. SP 661026-0 Multigerm 2 pounds

Same distribution as noted for Item 17.

II. Sugarbeet Investigations, Fort Collins, Colorado

Developments in breeding research by J. O. Gaskill.

Item 27. FC 701 Multigerm 3 pounds

From the available quantity the following amount is to be distributed now to the companies noted: Amalgamated - 10 gm; American Crystal - 25 gm; F & M - 10 gm; Holly - 25 gm; Spreckels - 30 gm; Utah-Idaho - 20 gm. The balance of the seed will be used for increase by the West Coast Beet Seed Company; the increase is to be shared by American Crystal, F & M, Great Western and Holly.

Utilization of USDA Seed Releases, 1967
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Item 28. FC 702 Multigerm 3 pounds

From the available quantity the following amount is to be distributed now to the companies noted:

Amalgamated - 50 gm; American Crystal - 25 gm; F & M - 10 gm; Holly - 25 gm; Spreckels - 30 gm; Utah-Idaho - 20 gm. The balance of the seed will be used for an increase by the West Coast Beet Seed Company; the increase is to be shared by American Crystal, F & M, Great Western and Holly.

III. Plant Industry Station, Beltsville, Maryland

Developments in breeding research by G. E. Coe.

Item 29. SP 67503-01 Monogerm 1 pound

The available quantity will be distributed among the following companies: American Crystal, Great Western, Holly and Spreckels.

Item 30. SP 67519-01 Monogerm 1 pound

Same distribution as noted for Item 29.

Item 31. SP 67547-01 Monogerm 1 pound

Same distribution as noted for Item 29.

Item 32. SP 67550-01 Monogerm 1 pound

Same distribution as noted for Item 29.

Item 33. SP 67552-01 Monogerm 1 pound

Same distribution as noted for Item 29.

Item 34. SP 67555-01 Monogerm 1 pound

Same distribution as noted for Item 29.

SUGARBET SEED PRODUCTION IN UNITED STATES, 1955-1967^{1/}

Year of production	100-pound bags			Percent monogerm
	Total	Multigerm	Monogerm	
1955	114,187	114,152	35	Trace
1956	88,279	84,991	3,431	3.9
1957	94,547	83,812	10,735	11.4
1958	109,832	82,571	27,261	24.8
1959	111,788	83,594	28,194	25.2
1960	124,545	49,869	74,676	60.0
1961	95,541	25,227	70,314	73.6
1962	93,416	10,768	82,648	88.5
1963	94,447	12,487	81,960	86.8
1964	133,614	15,777	117,837	88.2
1965	93,363	671	92,692	99.3
1966	139,020	4,700	134,320	96.6
1967	85,412	3,979	81,433	95.3

^{1/} Production records from Agricultural Statistics.

P A R T I I

Progress reports of research conducted at
U.S. Agricultural Research Station, Salinas, California
and
U.S. Southwest Irrigation Field Station, Brawley, California
and
Arizona Agricultural Experiment Station, Mesa, Arizona
by the
Staff of Sugarbeet Investigations, ARS-USDA
in cooperation with:

American Crystal Sugar Company
Holly Sugar Corporation
Union Sugar Division, C. F. Company
Spreckels Sugar Company
California Beet Growers Association
Beet Sugar Development Foundation

Research was conducted by:

J. S. McFarlane	B. L. Hammond
I. O. Skoyen	J. M. Fife
R. T. Lewellen	D. L. Doney
K. D. Beatty	E. D. Whitney
Helen Savitsky	E. G. Ruppel
C. W. Bennett	

DEVELOPMENT AND EVALUATION OF INBRED LINES AND
HYBRID VARIETIES SUITABLE FOR CALIFORNIA ✓

Summary of Accomplishments - 1967

Foundation projects 12 and 24 are closely related and the accomplishments of the two projects overlap. The most important breeding contribution from the Salinas Station in 1967 was the development of the varieties US H9A and US H9B. These hybrids utilize the yellows-resistant selection 413 as the pollen parent. The performance of these hybrids is discussed and summarized on page 73 which deals with yellows investigations. The US H9 hybrids not only perform well under conditions of severe yellows but also perform better than US H7 when yellows infection is light. Tests during the past three years have shown these new hybrids to be slightly superior to US H7 in bolting and curly top resistance.

BOLTING RESISTANCE--Bolting-resistance evaluations were made from November and December plantings at Salinas and from an October planting at Tracy. Both US H9A and US H9B showed significantly less bolting in the Salinas November planting than did US H7. At Tracy, US H9A bolted 66 percent whereas US H7 bolted 82 percent. The curly top resistant monogerm inbred 564 and its male sterile equivalent tended to be more susceptible to bolting than either 562 or 563. 564 is being increased for use as a seed-bearing parent. Further tests should be made to determine the bolting resistance of F_1 hybrids with 564.

CURLY TOP RESISTANCE--A reliable greenhouse method of selecting for curly top resistance in the sugarbeet has been developed. Viruliferous beet leafhoppers are caged on seedlings for one week and the plants are graded for severity of symptoms six weeks after inoculation. Plants with the mildest symptoms are selected and selfed seed produced. At least eight plants of each selfed progeny are tested. Those progenies showing the best resistance are retested through the use of a larger number of plants. The mass selection method, commonly used in the field, does not work as well in the greenhouse because of plant variation caused by environmental factors. Progeny tests are necessary and are made most readily with self-fertile populations of sugarbeet. Monogerm inbred lines with a high level of resistance to the more virulent curly top strains have been developed. These lines are being tested for bolting resistance and seed setting ability. Male sterile lines with high resistance are being developed.

1/ J. S. McFarlane, B. L. Hammond, K. D. Beatty, and I. O. Skoyen

DOWNY MILDEW RESISTANCE--Downy mildew was one of the most damaging diseases of the sugarbeet in the coastal valleys of California prior to 1954. Open-pollinated varieties with moderate resistance were developed and these replaced susceptible varieties in the early 1950s. Monogerm hybrid varieties with moderate resistance have now replaced the open-pollinated varieties. The disease has been of minor importance since the moderately resistant varieties have come into general use. Although none of our present varieties is highly resistant, the level of resistance appears to be sufficient to prevent widespread infection and damage.

Even though mildew has not been an economic problem in recent years, the potential for infection and economic loss still exists. As new varieties are developed, breeders should strive to maintain at least the present level of resistance. The possible appearance of new strains of Peronospora schachtii should not be overlooked. The sugarbeet is heterozygous for mildew resistance and selections have been made which are more resistant than our present varieties. If needed, this resistance could be incorporated into adapted varieties.

No mildew was observed in experimental plantings at Salinas nor in the adjacent commercial fields during 1967 and evaluations could not be made for mildew resistance.

POLYPLOIDY--Dr. B. L. Hammond produced additional autotetraploids from self-sterile and self-fertile breeding lines. Progress was made in developing tetraploid, monogerm male steriles for possible use as seed-bearing parents in hybrids. Additional triploid hybrids with tetraploid pollen parents were produced for testing in 1968. Results with triploids utilizing yellows-resistant selections as pollen parents are discussed on page 58.

SEED LOTS MADE AVAILABLE THROUGH THE FOUNDATION:

C613 -- A yellows-resistant selection from US 75. Seven successive selections were made on the basis of root size and freedom from yellowing. Hybrids utilizing C613 as the pollen parent were found to give a similar performance as did hybrids with C413. A seed increase is being made of C613.

C630T -- Increase of a tetraploid derived from the yellows-resistant C330 (Item 5, 1963), a selection from US 75. Two tests at Salinas in 1967 failed to show any significant differences in the yield and sucrose percentage of (562HO x 569) x 630T and the corresponding diploid hybrid. Additional tests are being made in 1968.

C786T -- Increase of a tetraploid derived from a bolting-resistant, high sucrose selection from US 22.

C7601 -- A monogerm, curly top resistant inbred derived from S₂(871 x 0561-16-1). Greenhouse tests made in 1966 and 1967 showed C7601 to have high resistance to the virulent strains of the curly top virus. The line proved to be a poor seed producer in Oregon and should be used as breeding line and not directly as a parent in hybrids.

C5760 -- A multigerm inbred line derived from a cross between a yellows-resistant selection from US 75 and a yellows-resistant self-fertile line. C5760 has shown excellent vigor and good yellows resistance. It has good resistance to bolting and curly top.

Percent bolting in sugarbeet inbreds and F₁ hybrids
planted at Salinas, California, November 18, 1966:

Entry		Date of Counting	
No.	Description	7/19/67	8/6/67
		Percent	Percent
<u>Inbreds</u>			
4664-3	mm inbred	0.4	0.4
6547T	NB5 (Tetra)	0.9	0.8
F60-512	NB6	0.8	1.7
1547	NB5	0.4	2.1
F65-563	mm inbred	5.9	11.8
F66-550	mm inbred	8.4	12.6
F65-563HO	MS of 563	6.4	14.3
F66-563	mm inbred	11.4	15.2
F66-546	mm inbred	10.5	15.5
F63-546	mm inbred	11.9	17.9
F64-550	mm inbred	13.8	18.7
F66-569	mm inbred	12.4	19.2
F66-563HO	MS of 563	13.0	19.4
F66-562HO(K)	MS of 562	12.1	20.3
F66-562(K)	mm inbred	12.5	20.4
F66-562HO(H)	MS of 562	12.6	20.6
0539	NB7	13.5	23.8
F64-562HO	MS of 562	16.0	25.6
F64-562	mm inbred	21.4	27.7
F63-563HO	MS of 563	16.6	27.8
3539T	NB7 (Tetra)	21.9	29.3
F66-562(H)	mm inbred	21.3	32.0
F64-569	mm inbred	30.9	38.8
F59-502HO	MS of NB1	28.1	39.0
5564HO	MS of 564	30.3	39.2
5564	mm inbred	32.9	43.6
F56-502	NB1	29.8	47.2
<u>F₁ Hybrids</u>			
5753H4	563HO x 753	13.5	19.9
4716H3	562HO x 716-18	15.7	25.6
5754H4	563HO x 754	20.4	36.9
5760H4	563HO x 760	28.7	42.7
6705H24	5760H4 x 705	31.7	49.0
L.S.D. (5%)		--	9.5

BOLTING NURSERY 1966-1967

Holly Sugar
Corporation

Tracy, California

Planted: 10-11-66

Counted: 6-20-67

Plots 1 row (30") x 27 feet

VARIETY	SOURCE OR DESCRIPTION	AVERAGE 4 REPS. BOLTING %
F57-63	C663 L7341	86
USH7	L6431	88
US48	L5517	92
US75	L443 C368	51
US75	F57-68	69
F64-30	YRS US75	67
L13C	YRS US75	73
544	330 x 234	88
534	Rietberg YRS	87
USH6	L6342	79
USH7	L6344	82
US48	L53944	75
L53948	(562Ho x 546) x NB7	73
L6348	(562Ho x 546) x 663	86
L64411	(563Ho x 550) x L464	80
664411	(563Ho x 534) x L464	79
5402411	(563Ho x 550) x 5402	89
540244	(562Ho x 569) x 5402	90
F66-1344	(562Ho x 569) x L13	66
F66-13411	(563Ho x 550) x L13	65
F63-64	BRS 663	62
663 (tetra)	F62-63T	71
3425	663 tetra x NB7 tetra	47
640344	(562Ho x 569) x 6403	78
6403411	(563Ho x 550) x 6403	90
NB2	Cal 7133 (C511)	83
NBLMS	F59-502Ho	47
NB1	F56-502	38
Cal A 7135	NB1 x NB2	82
154741	NB1 x NB5	65
F59-512H1	NB5 x NB6	27
NB5	F59-547A L9458	51
NB6	F59-512	0
NB3	F57-509 L7389	89
NB7	O539	42
562	F61-562 (mm)	24
562MS	F64-562Ho (mm)	68
F63-54643	562Ho x 546	63
F64-569H3	562Ho x 569	69
F60-5694o	L0393 F59-569Ho x 8569	74
550	F64-550 (mm)	68
F66-55044	L6223	50
5563MS	5563Ho	46
563	5563 (mm)	52
F66-569H3	L6291	56
F58-85Ho	NB361Ho L8239	58

LEAF SPOT RESISTANCE EVALUATION OF SUGARBEET STRAINS

FURNISHED BY DR. J. S. McFARLANE, 1967

Hospital Farm, Fort Collins, Colorado

Experiment 16A

(Conducted by L. W. Lawson, B. A. Nelsen, and J. O. Gaskill)

Description	:Contributor's:Fort Collins:		Leaf spot ^{a/}				:Vigor ^{b/}
	: no.	: seed no.	:8/21:	8/27:	9/11:	8/16	
mm inbred from US 401	F64-648	Acc. 2693	2.5	3.7	2.8	4.7	
mm inbred from US 401	F64-649	Acc. 2694	1.2	2.0	1.3	4.7	
S ₂ (US 201 rr x 648-11)	5855C2	Acc. 2695	1.3	2.3	1.8	5.0	
S ₂ (563 x 648-11)	5834	Acc. 2696	2.3	3.8	3.3	4.0	
S ₂ (US 201 rr x 648-3)	6820	Acc. 2697	2.2	3.3	2.5	4.0	
648H3 x 6403	6403H15	Acc. 2698	3.0	4.2	3.5	6.0	
SP 5481-0		Acc. 2483	2.2	3.2	2.3	6.0	
SP 5822-0		Acc. 2644	1.5	2.3	2.0	5.7	
Synthetic Check		Acc. 2269	3.8	5.0	4.3	4.7	

^{a/} Leaf spot (B. A. Nelsen): 0 = no leaf spot; 10 = complete defoliation.

^{b/} Foliage Vigor (B. A. Nelsen): Higher no. = greater vigor.

Field Plan: Plots 2 rows x 12'; rows 20" apart; 3 plots of each strain. Artificial inoculation and frequent sprinkling were employed to promote the development of leaf spot.

Remarks: Stand was satisfactory throughout.

* * * * *

VARIETY TEST, SALINAS, CALIFORNIA, 1967

Location: Spence Field of the U.S. Agricultural Research Station.

Soil type: Sandy loam.

Fertilizer used: 800 lbs. per acre 0:10:10, preplant, broadcast and disced in before listing.
400 lbs. per acre ammonium sulfate for bolting test and 260 lbs. per acre for yield test, preplant.
170 lbs. per acre ammonium sulfate on bolting test and 260 lbs. per acre on yield test, sidedressed March 21, 1967.
285 lbs. per acre ammonium sulfate sidedressed May 16, 1967 on both tests.
175 lbs. per acre ammonium sulfate sidedressed July 10, 1967 on both tests.

Planting dates: Bolting test, November 18, 1966.
Yield test, December 20, 1966.

Thinning dates: Bolting test, January 14, 1967.
Yield test, February 16, 1967.

Harvest dates: Bolting test, September 12-13, 1967.
Yield test, October 3-12, 1967.

Irrigation: Sprinkler irrigation as required through May 1, 1967.
Subsequently, sprinkler irrigation used at 10-15 day intervals.

Diseases and insects: Symptoms of yellows virus infection showed extensively throughout the bolting test but were scattered in the yield tests by mid-April. Yellows virus infections were approaching 100 percent by early July. Tests were sprayed with Thiodan February 18 and March 7, and with Meta-systox R on March 23 and April 29 for control of green peach aphid.

Experimental design: Bolting test planted in a randomized block with four replications. Varieties planted in single-row plots; plots 68 feet long. One yield test of 10 varieties was planted in a 10 x 10 latin square with two-row plots. Two yield tests of 28 varieties each were planted in randomized block design with ten replications each. One test inoculated with yellows viruses. Single-row plots used for each test. Rows spaced 28 inches apart. Plots 53 feet long.

Sugar-purity analysis: From two samples per plot, of approximately ten roots each, at the sugar analytical laboratory, United States Agricultural Research Station, Salinas, California.

VARIETY TEST, SALINAS, CALIFORNIA, 1967

(4 replications of each variety)
(One-row plots)

Planted: November 18, 1966
Harvested: September 11, 1967

Variety	Description	Acre Yield		Sucrose Percent	Bolting Percent	Harvest Count Number
		Sugar Pounds	Beets Tons			
F66-13H11	(563HO x 550) x 13	12,020	42.68	14.1	10.2	173
534H11	(563HO x 550) x 34	11,930	41.70	14.3	8.5	165
534	Rietberg YRS	10,750	36.96	14.6	6.9	165
544H11	(563HO x 550) x 44	10,730	39.37	13.6	16.1	164
F66-13H4	(562HO x 569) x 13	10,690	38.69	13.8	7.0	168
613H29	(563HO x 754) x 13 sel.	10,310	37.96	13.6	10.8	173
464H11	(563HO x 550) x 64	10,310	37.30	13.8	16.5	165
613H4	(562HO x 569) x 13 sel.	10,250	37.05	13.8	11.6	167
413H8	(562HO x 546) x 13	9,890	34.86	14.2	6.5	156
613B	7th YRS US 75	9,800	34.55	14.2	10.0	178
413C	5th YRS US 75	9,750	34.30	14.2	8.4	168
544H4	(562HO x 569) x 44	9,710	34.47	14.1	10.8	172
F66-13	Increase 413	9,690	34.70	14.0	15.0	169
544	Increase (330 x 234)	9,620	34.22	14.1	17.7	172
664H8	(562HO x 546) x 64	9,210	32.47	14.2	14.2	178
664H4	(562HO x 569) x 64	9,150	31.72	14.4	14.3	184
4539H8	(562HO x 546) x NB7	8,980	32.93	13.7	16.6	177
664H2	(MS of NB1 x NB5) x 64	8,970	31.35	14.3	13.1	160
613H24	(563HO x 760) x 13 sel.	8,880	31.55	14.1	11.3	152
664H14	(563HO x 534) x 64	8,860	31.20	14.2	11.9	170
463H4	(562HO x 569) x 63	8,650	30.26	14.3	19.9	185
6539H4	(562HO x 569) x NB7	8,530	31.72	13.5	18.8	181
4539H4	(562HO x 569) x NB7	8,510	30.71	13.9	21.2	179
6403H11	(563HO x 550) x 403	8,310	29.21	14.2	30.9	175
6403H4	(562HO x 569) x 403	8,300	29.35	14.2	39.0	169
6705H24	(563HO x 760) x 705	8,030	28.84	14.0	37.6	170
F66-546H3	562HO x 546	7,820	26.97	14.5	10.5	178
F66-64	BRS 663	7,700	28.37	13.6	11.7	181
4539H11	(563HO x 550) x NB7	7,680	28.16	13.6	12.8	165
F66-550H4	563HO x 550	7,450	26.38	14.1	5.5	170
F57-68	US 75	6,800	24.31	14.0	10.5	172
F66-569H3	562HO x 569	6,790	23.19	14.7	7.2	179

General MEAN of all varieties	9,190	32.73	14.1	14.5	Beets
Significant Difference (19:1)	1,060	3.98	0.58	6.5	per
Coefficient of Variation (%)	8.21	8.66	2.91	31.99	100'
Calculated F value	12.10**	11.17**	2.14**	12.27**	row

** Exceeds the 1% point of significance (F=2.06)

VARIETY TEST, SALINAS, CALIFORNIA, 1967

(10 x 10 Latin Square)
(Two-row plots)

Planted: December 20, 1966
Harvested: September 11, 1967

Variety	Description	Acre Yield		Bolting Percent	N PPM	Na PPM	K PPM	Imp. Index	Harvest Count Number
		Sugar	Beets						
		Pounds	Tons						
F66-13H11	(563H0 x 550) x 13	10,230	36.83	5.6	588	265	2,065	864	132
F66-13H4	(562H0 x 569) x 13	10,070	36.26	3.0	593	239	2,199	885	131
613H4	(562H0 x 569) x 13 sel.	10,050	36.96	6.6	671	279	2,282	986	136
613H24	(563H0 x 760) x 13 sel.	9,880	35.50	8.9	631	192	2,156	891	131
464H11	(563H0 x 550) x 64	9,280	34.80	11.4	601	376	2,151	955	136
664H8	(562H0 x 546) x 64	9,130	33.40	8.1	629	387	2,233	970	145
664H4	(562H0 x 569) x 64	9,090	33.27	4.9	668	334	2,308	1,000	142
4539H4	(562H0 x 569) x NB7	8,840	32.56	27.3	646	343	1,774	892	139
664H2	(MS of NB1 x NB5) x 64	8,820	32.09	5.5	637	311	2,272	958	136
6403H4	(562H0 x 569) x 403	8,220	29.50	26.5	513	301	2,000	803	128
General MEAN of									
all varieties		9,360	34.12	13.7	618	303	2,144	920	Beets
Significant Difference (19:1)		337	1.02	NS	56	91	129	64	per
Coefficient of Variation (%)		4.04	3.36	3.22	23.27	10.11	33.66	7.86	100'
Calculated F value		31.02**	43.65**	NS	123.01**	5.58**	3.56**	12.54**	7.57** row

** Exceeds the 1% point of significance (F=2.67)

VARIETY TEST, BRAWLEY, CALIFORNIA, 1967

Location: U.S. Department of Agriculture, Southwestern Irrigation Field Station. 1/

Soil type: Holtville silty clay loam.

Previous crops: Sugarbeets, 1965 and 1966; sweet sorghum and barley, 1964.

Fertilizer used: 42 lbs. per acre phosphorus, actual, preplant.
22 lbs. per acre nitrogen, actual, preplant.
180 lbs. per acre nitrogen, actual, sidedressed
October 27-28, 1966.

Planting date: September 20, 1966.

Thinning date: October 20-21, 1966.

Harvest dates: Early harvest, May 17-19, 1967.
Late harvest, June 28, 1967.

Irrigations: Early harvest, 10 by furrow.
Late harvest, 12 by furrow.

Diseases and insects: Symptoms of yellows virus infections were evident throughout the tests in January, 1967. Curly top virus infection was light in the 1966-67 test. The tests were sprayed October 8 with malathion and on October 21 with Guthion for control of striped cabbage beetle, desert flea beetle and webworm. On November 11 the tests were sprayed with methyl parathion for control of cabbage looper.

Experimental design: Planted for early harvest, test 1, fourteen varieties in two-row plots, and test 2, sixteen varieties in single-row plots, each with ten replications and in randomized block design. Planted for late harvest, test 1, ten varieties in two-row plots and, test 2, ten varieties in single-row plots, each in 10 x 10 latin square design. Rows spaced 30 inches apart. Plots 40 feet long.

Sugar analysis: From two ten-beet samples per plot by Holly Sugar Corporation, Brawley, California.

Remarks: Test designed and results analyzed by the United States Agricultural Research Station, Salinas, California.

1/ Tests were under supervision of K. D. Beatty stationed at Southwestern Irrigation Field Station, Brawley, California.

VARIETY TEST, BRAWLEY, CALIFORNIA, 1967

(10 replications of each variety)
(Two-row plots)

Planted: Sept. 20, 1966
Harvested: May 18, 1967

Variety	Description	Acre Yield		Sucrose Percent	Harvest Count Number
		Sugar Pounds	Beets Tons		
F66-13H11	(563HO x 550) x 13	9,220	30.54	15.1	131
413H8	(562HO x 546) x 13	9,130	30.89	14.8	119
F66-13H4	(562HO x 569) x 13	9,080	30.45	15.0	125
544H4	(562HO x 569) x 44	8,380	28.03	15.0	116
544H11	(563HO x 550) x 44	8,380	28.10	14.9	122
464H11	(563HO x 550) x 64	8,010	26.58	15.1	117
463H2	(MS of NB1 x NB5) x 63	7,950	26.74	14.9	111
463H8	(562HO x 546) x 63	7,610	25.22	15.1	122
4539H4	(562HO x 569) x NB7	7,510	24.42	15.4	121
664H14	(563HO x 534) x 64	7,380	25.25	14.7	105
463H4	(562HO x 569) x 63	7,380	24.76	14.9	131
5402H4	(562HO x 569) x 402	7,150	24.23	14.8	106
6403H4	(562HO x 569) x 403	6,580	22.76	14.5	89
6403H11	(563HO x 550) x 403	6,140	21.38	14.4	98
General MEAN of all varieties		7,850	26.38	14.9	Beets
S. E. of MEAN		210	0.72	0.17	per
Significant Difference (19:1)		586	2.01	0.48	100'
Coefficient of Variation (%)		8.02	8.16	3.62	row

Odds 19:1 = 1.979 x $\sqrt{2}$ x Standard Error of MEAN

VARIANCE TABLE

Variation due to	Degrees of Freedom	M E A N S Q U A R E S		
		Gross Sugar	Tons Beets	Percent Sucrose
Between varieties	13	9,612,985	95.34	0.74
Between replications	9	2,435,048	43.99	1.40
Remainder (Error)	117	439,160	5.14	0.29
Total	139			
Calculated F value		21.89**	18.55**	2.56**

** Exceeds the 1% point of significance (F=2.33)

VARIETY TEST, BRAWLEY, CALIFORNIA, 1967

(10 replications of each variety)
(One-row plots)

Planted: Sept. 20, 1966
Harvested: May 17, 1967

Variety	Description	Acre Yield		Sucrose Percent	Harvest Count Number
		Sugar Pounds	Beets Tons		
613H24	(563H0 x 760) x 13 sel.	9,160	32.78	14.0	119
613H29	(563H0 x 754) x 13 sel.	9,050	33.08	13.7	138
544	Increase (330 x 234)	8,950	31.26	14.3	104
413C	5th YRS US 75	8,910	31.18	14.3	104
613H4	(562H0 x 569) x 13 sel.	8,790	31.99	13.8	112
613B	7th YRS US 75	8,740	31.28	14.0	113
630	7th YRS US 75	8,180	29.11	14.0	121
637	3rd YRS 63	8,130	28.95	14.0	127
463H2	(MS of NBl x NB5) x 63	7,840	27.96	14.0	117
534	Rietberg YRS	7,840	25.88	15.2	114
F63-64	BRS 63	7,500	26.60	14.1	102
FS4H4	(562H0 x 569) x FS4	6,930	24.78	14.0	133
FS5	Fife YRS US 75	6,670	22.83	14.6	126
FS4	Fife YRS US 75	6,630	23.19	14.3	126
FS7	Fife YRS US 75	6,490	22.13	14.6	113
F57-68	US 75	6,290	22.58	14.0	122
General MEAN of all varieties		7,880	27.85	14.2	Beets
S. E. of MEAN		302	0.99	0.21	per
Significant Difference (19:1)		845	2.78	0.60	100'
Coefficient of Variation (%)		12.12	11.28	4.76	row

Odds 19:1 = $1.979 \times \sqrt{2}$ x Standard Error of MEAN

VARIANCE TABLE

Variation due to	Degrees of Freedom	M E A N S Q U A R E S		
		Gross Sugar	Tons Beets	Percent Sucrose
Between varieties	15	10,308,263	152.25	1.36
Between replications	9	1,161,750	11.86	0.56
Remainder (Error)	135	912,427	9.87	0.46
Total	159			
Calculated F value		11.30**	15.43**	2.98**

** Exceeds the 1% point of significance (F=2.15)

VARIETY TEST, BRAWLEY, CALIFORNIA, 1967

(10 x 10 Latin Square)
(Two-row plots)

Planted: September 20, 1966
Harvested: June 28, 1967

Variety	Description	Acre Yield		Sucrose Percent	Harvest Count Number
		Sugar Pounds	Beets Tons		
F66-13H11	(563H0 x 550) x 13	9,440	33.59	14.1	130
F66-13H4	(562H0 x 569) x 13	9,150	32.85	13.9	129
463H2	(MS of NB1 x NB5) x 63	7,730	28.36	13.6	108
464H11	(563H0 x 550) x 64	7,700	28.49	13.5	111
463H8	(562H0 x 546) x 63	7,410	27.61	13.4	115
4539H4	(562H0 x 569) x NB7	7,120	25.68	13.9	118
463H4	(562H0 x 569) x 63	6,820	25.87	13.2	121
664H14	(563H0 x 534) x 64	6,510	24.31	13.2	106
6403H4	(562H0 x 569) x 403	6,050	22.47	13.5	85
6403H11	(563H0 x 550) x 403	5,610	21.05	13.3	100

General MEAN of all varieties	7,350	27.03	13.6	Beets
S. E. of MEAN	174	0.63	0.11	per
Significant Difference (19:1)	490	1.77	0.32	100'
Coefficient of Variation (%)	7.47	7.32	2.65	row

Odds 19:1 = $1.994 \times \sqrt{2}$ x Standard Error of MEAN

VARIANCE TABLE

Variation due to	Degrees of Freedom	M E A N S Q U A R E S		
		Gross Sugar	Tons Beets	Percent Sucrose
Between varieties	9	15,140,667	164.68	0.92
Between replications	9	1,182,464	14.17	1.23
Between columns	9	731,850	5.49	1.35
Remainder (Error)	72	301,804	3.92	0.13
Total	99			

Calculated F value 50.17** 42.01** 7.12**

** Exceeds the 1% point of significance (F=2.67)

VARIETY TEST, BRAWLEY, CALIFORNIA, 1967

(10 x 10 Latin Square)
(One-row plots)

Planted: September 20, 1966
Harvested: June 27, 1967

Variety	Description	Acre Yield		Sucrose Percent	Harvest Count Number
		Sugar Pounds	Beets Tons		
613H4	(562H0 x 569) x 13 sel.	9,800	35.71	13.7	115
613B	7th YRS US 75	9,090	32.23	14.1	93
544	Increase (330 x 234)	8,810	31.06	14.2	117
463H2	(MS of NB1 x NB5) x 63	8,150	29.45	13.8	132
534	Rietberg YRS	7,590	26.31	14.5	110
FS4H4	(562H0 x 569) x FS4	7,050	25.77	13.7	134
FS5	Fife YRS US 75	6,450	22.22	14.4	127
FS4	Fife YRS US 75	6,410	23.32	13.7	137
FS7	Fife YRS US 75	5,860	20.75	14.2	132
F57-68	US 75	5,480	20.74	13.2	126

General MEAN of all varieties	7,470	26.76	13.9	Beets
S. E. of MEAN	220	0.8	0.19	per
Significant Difference (19:1)	621	2.26	0.52	100'
Coefficient of Variation (%)	9.32	9.45	4.21	row

Odds 19:1 = $1.994 \times \sqrt{2}$ x Standard Error of MEAN

VARIANCE TABLE

Variation due to	Degrees of Freedom	M E A N S Q U A R E S		
		Gross Sugar	Tons Beets	Percent Sucrose
Between varieties	9	21,336,695	268.49	1.46
Between replications	9	1,926,431	19.92	1.20
Between columns	9	1,398,910	17.62	0.28
Remainder (Error)	72	484,593	6.40	0.34
Total	99			
Calculated F value		44.03**	41.95**	4.24**

** Exceeds the 1% point of significance (F=2.67)

VARIETY TEST CLARKSBURG, CALIFORNIA, 1967

Variety	Description	By American Crystal Sugar Co.				
		Lbs. Sugar Per Acre	Known a/ Sugar Loss	Tons Per Acre	Percent Sucrose	Impurity Index
Am #5 Hybrid	569H3 + 546H3 x NB7	3913	387	15.46	12.63	603
F66-13H4	(562H0 x 569) x 413	4138	447	15.98	12.94	721
F66-13H11	(563H0 x 550) x 413	4090	444	16.25	12.60	726
US H7	(562H0 x 569) x 663	4073	443	15.43	13.16	723
US H7A	(562H0 x 546) x 663	4076	450	15.85	12.89	736
463H11	(562H0 x 550) x 663	4445	496	17.53	12.70	744
74842	546H3 x Klein 2n	4312	446	16.24	13.31	687
General Mean		4027.8		15.33	13.17	689
LSD (0.05)		288.5		1.13	.39	39.5
LSD (0.01)		383.2		1.51	.52	52.5
F Value		8.13**		12.50**	10.34**	8.44**
C. V. %		7.64%		7.89%	3.15%	6.12%

a/ Known sugar loss into molasses from Impurity Index.

** Significant at the 1% level.

Notes: Randomized block design, 9 replications of 2 row plots, 30" between rows, rows 35 feet long.
17 ft. 5 inches of each row harvested for yield and sugar percent and quality data.

Planted: June 13.

Harvested: October 23.

DATA ON U.S.D.A. VARIETIES TESTED BY SPRECKELS SUGAR COMPANY, 1967

TEST AREAS:	S A N L U C A S			G R E E N F I E L D		
	<u>Sugar</u> <u>T/Ac.</u>	<u>Beets</u> <u>T/Ac.</u>	<u>%</u> <u>Sugar</u>	<u>Sugar</u> <u>T/Ac.</u>	<u>Beets</u> <u>T/Ac.</u>	<u>%</u> <u>Sugar</u>
Variety						
US H7	4.415	32.53	13.6	3.703	31.66	11.6
US H8				3.456	30.74	11.1
664H8	4.286	31.52	13.6			
F66-13H11	4.584	33.39	13.7			
F66-13H4	5.145	35.97	14.3	4.370	38.23	11.4
GENERAL MEAN	4.452	31.98	13.9	3.443	30.12	11.3
LSD @ P = .05	0.579	3.82	0.85	0.542	4.15	0.71
LSD @ P = .01	0.768	5.06	1.12	0.724	5.53	0.95
S E of MEAN	0.205	1.35	0.30	0.191	1.52	0.25
S E % of MEAN	4.60	4.23	2.16	5.55	5.05	2.21
No. Var. in Test		12			8	
Planting Date		1-5-67			2-14-67	
Harvest Date		9-19-67			10-16-67	

DATA ON U.S.D.A. VARIETIES TESTED BY SPRECKELS SUGAR COMPANY, 1967

TEST AREAS:	A L I S A L			S P R E C K E L S		
	<u>Sugar</u> <u>T/Ac.</u>	<u>Beets</u> <u>T/Ac.</u>	<u>%</u> <u>Sugar</u>	<u>Sugar</u> <u>T/Ac.</u>	<u>Beets</u> <u>T/Ac.</u>	<u>%</u> <u>Sugar</u>
<u>Variety</u>						
US H7	4.605	33.56	13.7	3.795	23.50	16.1
US H8	4.284	31.81	13.5			
4539H12				3.427	21.78	15.8
F66-13H4	4.431	32.56	13.5			
GENERAL MEAN	4.357	32.11	13.6	3.062	19.53	15.6
LSD @ P = .05	NS	NS	NS	0.531	3.37	0.51
LSD @ P = .01	NS	NS	NS	0.706	4.48	0.68
S E of MEAN	0.201	1.39	0.27	0.188	1.19	0.18
S E % of MEAN	4.61	4.34	1.99	6.14	6.11	1.15
No. Var. in Test		8			10	
Planting Date		12-22-66			12-29-66	
Harvest Date		9-27-67			8-30-67	

DATA ON U.S.D.A. VARIETIES TESTED BY SPRECKELS SUGAR COMPANY, 1967

TEST AREAS: Variety	M A N T E C A			D I X O N			M E N D O T A		
	<u>Sugar T/Ac.</u>	<u>Beets T/Ac.</u>	<u>% Sugar</u>	<u>Sugar T/Ac.</u>	<u>Beets T/Ac.</u>	<u>% Sugar</u>	<u>Sugar T/Ac.</u>	<u>Beets T/Ac.</u>	<u>% Sugar</u>
US H7	5.94	35.8	16.6	5.100	32.34	15.8	5.08	40.9	12.4
US H8	5.43	33.6	16.1	4.975	30.84	16.2	4.59	34.6	13.2
463HL2	6.21	37.7	16.5	5.678	34.58	16.4			
463HL1	6.03	37.2	16.2						
664HL4							5.28	40.7	12.8
363H8	6.16	37.7	16.3	5.693	35.34	16.1			
4539H8	5.57	34.7	16.1	5.216	32.78	15.9			
4539HL2				4.770	30.63	15.6	3.92	31.2	12.6
GENERAL MEAN	5.873	36.07	16.3	5.249	32.91	16.0	4.56	37.1	12.3
LSD @ P = .05	0.337	1.82	NS	0.478	3.07	0.45	0.622	4.79	NS
LSD @ P = .01	0.450	2.43	NS	0.638	NS	NS	0.825	6.35	NS
S E of MEAN	0.119	0.641	0.163	0.168	1.081	0.159	0.220	1.699	0.35
S E % of MEAN	2.03	1.78	1.00	3.20	3.28	0.99	4.82	4.57	2.86
No. Var. in Test	8			8			16		
Planting Date	5-12-66			5-13-66			3-1-67		
Harvest Date	5-3-67			5-12-67			10-10-67		

VARIETY TEST - 1967

IMPERIAL VALLEY, CALIF.

IMPERIAL VALLEY USDA

COOP: NELSON B. CORRELL

Variety	Source	Acre Yield		Percent Sucrose	Percent Purity	No. Beets 100' Row
		Gross Sugar	Tons Beets			
F66-13H11	(563H0x550)x413	9059	29.469	15.37	86.8	186
USH9A	569H3x413	8692	27.316	15.91	87.3	188
464H11	3550H4 x 464	8374	28.272	14.81	87.0	173
463H8	546H3 x 663	7806	25.609	15.24	87.5	192
4539H4	USH8 569H3xNB7	7618	25.158	15.14	87.2	185
463H4	USH7 569H3x663	7575	24.950	15.18	86.0	193
463H2	USH6 (NB1xNB5)x663	7285	24.813	14.68	85.7	188
4539H8	(562H0x546)xNB7	7160	23.883	14.99	86.6	186
Gen. Mean		7946	26.184	15.16	86.8	186
SE Mean		206A/	.586	.20	.57	
LSD (5%)		584	1.665	.56	1.62	
SEM/Gen. Mean (%)		2.59	2.24	1.30	.66	

VARIANCE TABLE

Variation Due to	Degrees of Freedom	Mean Square		
		Tons Beets	Percent Sucrose	Percent Purity
Variety	7	30.295	1.137	3.301
Replication	7	2.508	.588	29.489
Error	49	2.752	.309	2.609
Total	63			
Calc. F. Value		11.01**	3.68**	1.27NS
**Exceeds 1% level 2.88				
NS - Non-Significant				
A/ Short Cut Formula				

Plot Size: 2 rows (32") x 53' Planted
2 rows x 50' Harvested

Design: 8 x 8 Latin Square - 9 reps analyzed as a randomized block

Planted: 9-13-66 and 9-14-66

Harvested: 7-10-67 and 7-11-67

Harvest: Yield - entire plot; Sucrose - 2-25 lb. samples per plot.

Remarks: Good stand. Moderate infestation of virus yellows. Too long off water before harvest.

VARIETY TEST - 1967

IMPERIAL VALLEY, CALIF.

IMPERIAL VALLEY EARLY PLANT EARLY HARVEST

COOP: DON H. COX

Variety	Source	Acre Yield		Percent Sucrose	Percent Purity	No. Beets 100' Row
		Gross Sugar	Tons Beets			
USH9A	569H3x413	9945	29.883	16.64	91.0	158
F66-13H11	3550H1x413	9938	30.447	16.32	91.3	151
463H12	(563x569)x663	9093	28.221	16.11	91.0	154
463H11	(563H0x550)x464	8559	26.189	16.34	91.2	144
4539H12	(563H0x546)xNB7	8520	24.826	17.16	91.5	150
USH7	16431	8354	26.222	15.93	90.5	147
USH8	15421	8156	24.866	16.40	90.9	153
4539H8	(562H0x546)xNB7	8104	24.293	16.68	91.6	156
Gen. Mean		8702	26.501	16.42	90.9	136
SE Mean		231A/	.616	.21	.29	
LSD (5%)		645	1.717	.58	.82	
SEM/Gen.Mean (%)		2.65	2.32	1.28	.32	

VARIANCE TABLE

Variation Due to	Degrees of Freedom	Mean Square		
		Tons Beets	Percent Sucrose	Percent Purity
Variety	24	33.438	1.346	7.757
Replication	8	67.782	8.113	4.104
Error	192	3.413	.394	.775
Total	224			
Calc. F. Value		9.80**	3.41**	10.01**
**Exceeds 1% level 1.88				
A/ Short Cut Formula				

Plot Size: 2 rows (30") x 53' Planted
2 rows x 50' Harvested

Design: 5 x 5 Triple Lattice - 9 reps analyzed as a randomized block

Planted: September 9, 1966

Harvested: 5-5-67 to 5-9-67

Harvest: Yield - entire plot; Sucrose - 2-25 lb. samples per plot.

Remarks: Very good test. Stand was consistent throughout. The only disease present was a slight infestation of yellows.

Extracted from a test of 25 varieties

VARIETY TEST - 1967

IMPERIAL VALLEY, CALIF.

IMPERIAL VALLEY 1st DATE OF HARVEST

COOP: NELSON B. CORRELL

Variety	Source	Acre Yield		Percent Sucrose	Percent Purity	No. Beets
		Gross	Tons			100'
		Sugar	Beets			Row
F66-13H11	3550H4 x 413	9277	27.580	16.83	87.6	177
USH9A	569H3 x 413	9051	26.040	17.40	87.9	183
463H11	(563H0x550)x464	8155	24.351	16.78	88.1	170
4539H12	(563H0x546)xNB7	8007	22.867	17.48	87.4	158
664H14	(562H0x534)x464	7778	23.988	16.24	86.1	167
USH8	15421	7610	22.060	17.28	87.8	175
USH7	16431	7519	22.075	17.04	87.3	191
Gen. Mean		7900	23.268	16.99	87.4	159
SE Mean		205A/	.524	.22	.41	
LSD (5%)		572	1.464	.61	1.15	
SEM/Gen.Mean (%)		2.59	2.25	1.28	.47	

VARIANCE TABLE

Variation Due to	Degrees of Freedom	Mean Square		
		Tons Beets	Percent Sucrose	Percent Purity
Variety	19	21.924	.857	3.473
Replication	8	10.013	2.566	6.795
Error	152	2.472	.427	1.521
Total	179			
Calc. F. Value		8.87**	2.01**	1.63NS
**Exceeds 1% level 2.00				
NS - Non-Significant				
A/ Short Cut Formula				

Plot Size: 2 rows (32") x 53' Planted
2 rows x 50' Harvested

Design: 4 x 5 Rectangular Lattice - 9 reps analyzed as a randomized block

Planted: 9-13-66 and 9-14-66

Harvested: 5-15-67 and 5-16-67

Harvest: Yield - entire plot; Sucrose - 2-25 lb. samples per plot.

Remarks: Good stand in nearly all the plots. Moderate infestation of virus yellows.

Extracted from a test of 20 varieties.

VARIETY TEST - 1967

IMPERIAL VALLEY, CALIF.

IMPERIAL VALLEY 2nd DATE OF HARVEST

COOP: NELSON B. CORRELL

Variety	Source	Acre Yield		Percent Sucrose	Percent Purity	No. Beets 100' Row
		Gross Sugar	Tons Beets			
F66-13H11	3550H4x413	10089	32.402	15.59	90.7	157
USH9A	569H3x413	9684	30.652	15.89	90.1	175
463H11	(563H0x550)x464	8468	28.211	15.02	90.9	154
664H14	(562H0x534)x464	8121	27.131	15.01	90.1	168
USH8	15421	8059	26.753	15.51	91.0	186
4539H12	(563H0x546)NB7	7773	25.302	15.41	91.3	162
USH7	16431	7722	24.973	15.52	89.9	172
Gen. Mean		8238	26.687	15.48	90.7	174
SE Mean		240A/	.706	.192	.35	
LSD (5%)		672	1.974	.535	.97	
SEM/Gen.Mean (%)		2.92	2.65	1.24	.38	

VARIANCE TABLE

Variation Due to	Degrees of Freedom	Mean Square		
		Tons Beets	Percent Sucrose	Percent Purity
Variety	19	37.033	1.092	2.819
Replication	8	41.644	9.545	3.726
Error	152	4.492	.330	1.076
Total	179			
Calc. F. Value		8.24**	3.31**	2.62**

**Exceeds 1% level 2.00

A/Short Cut Formula

Plot Size: 2 rows (32") x 53' Planted
2 rows x 50' Harvested

Design: 4 x 5 Rectangular Lattice - 9 reps analyzed as a randomized block

Planted: 9-13-66 and 9-14-66

Harvested: 6-13-67 and 6-14-67

Harvest: Yield - entire plot; Sucrose - 2-25 lb. samples per plot.

Remarks: Good stand in nearly all of the plots. Moderate infestation of virus yellows. Some problem with irrigation when drying up 1st Date of Harvest.

Extracted from a test of 20 varieties.

VARIETY TEST - 1967

IMPERIAL VALLEY, CALIF.

IMPERIAL VALLEY 3rd DATE OF HARVEST

COOP: NELSON B. CORRELL

Variety	Source	Acre Yield		Percent Sucrose	Percent Purity	No. Beets 100' Row
		Gross Sugar	Tons Beets			
F66-13H11	3550H4x413	9397	29.943	15.70	88.4	189
USH9A	569H3x413	9010	28.278	15.94	88.6	201
463H11	(563HOx550)x464	7745	26.247	14.76	87.9	194
664H14	(562HOx534)x464	7662	25.758	14.89	86.9	189
USH7	16431	7562	24.606	15.39	87.4	206
USH8	15421	7512	25.190	14.93	86.4	190
4539H12	(563HOx546)xNB7	7030	23.689	14.85	87.0	183
Gen. Mean		7675	25.145	15.27	87.7	176
SE Mean		185A/	.567	.13	.43	
LSD (5%)		515	1.583	.36	1.21	
SEM/Gen. Mean (%)		2.40	2.25	.84	.49	

VARIANCE TABLE

Variation Due to	Degrees of Freedom	Mean Square		
		Tons Beets	Percent Sucrose	Percent Purity
Variety	19	24.485	.939	3.927
Replication	8	14.125	.899	5.203
Error	152	2.890	.148	1.682
Total	179			
Calc. F. Value		8.47**	6.36**	2.34**
**Exceeds 1% level 2.00				
A/ Short Cut Formula				

Plot Size: 2 rows (32") x 53' Planted
2 rows x 50' Harvested

Design: 4 x 5 Rectangular Lattice - 9 reps analyzed as a randomized block

Planted: 9-13-66 and 9-14-66

Harvested: 7-10-67 and 7-11-67

Harvest: Yield - entire plot; Sucrose - 2-25 lb. samples per plot.

Remarks: Good stand. Moderate infestation of virus yellows too long off water before harvest.

Extracted from a test of 20 varieties

VARIETY TEST -- 1967

TRACY, CALIFORNIA

TRACY LATE PLANT

COOP: ED THOMING

Variety	Source	Acre Yield		Percent Sucrose	Percent Purity	No. Beets 100' Row
		Gross Sugar	Tons Beets			
534H11	(563H0x550)x234	9466	28.860	16.4	92.8	127
544H11	(563H0x550)x544	8807	26.367	16.7	93.3	143
544H4	(562H0x569)x544	8618	25.957	16.6	92.1	142
464H11	(563H0x550)x264	8593	27.194	15.8	91.7	119
USH6	463H2	8238	25.116	16.4	92.1	139
USH7	L3528 F63-64H4	7922	23.301	17.0	93.2	153
USH8	L5517	7158	21.823	16.4	92.3	152
Gen. Mean		8196	24.652	16.6	92.6	139
SE Mean		439A/	1.218	.344	.467	
LSD(5%)		1227	3.403	.958	1.302	
SEM/Gen. Mean (%)		5.36	4.94	2.07	.50	

VARIANCE TABLE

Variation Due to	Degrees of Freedom		Mean Square		
			Tons Beets	Percent Sucrose	Percent Purity
	Beets-Sucrose				
Variety	24	24	37.498	1.859	4.518
Replication	6	8	98.433	12.095	18.889
Error	144	192	10.386	1.063	1.963
Total	174	224			
Calc. F. Value			3.61**	1.75*	2.301**
**Exceeds 1% level 1.91					
* Exceeds 5% level 1.57					
A/ Short Cut Formula					

Plot Size: 2 rows (30") x 53' planted
2 rows x 50' harvested

Design: 5 x 5 Triple Lattice - 9 reps analyzed as a randomized block

Planted: May 11, 1966

Harvested: March 3, 1967

Harvest: Yield - entire plot; Sucrose 2-25 lb. samples per plot.

Remarks: Light fairly uniform infection of curly top. Two replications for yield lost due to a well being drilled in the test area.

Extracted from a test of 25 varieties

VARIETY TEST - 1967

TULARE, CALIFORNIA

SOUTH SAN JOAQUIN EARLY PLANT

COOP: PORTER ESTATES

Variety	Source	Acre Yield		Percent Sucrose	Percent Purity	Percent Bolters	No. Beets 100'
		Gross Sugar	Tons Beets				Row
USH9A	569H3xC413	9080	37.959	11.96	86.6	4.0	177
F66-13H11	3550H1xC413	8724	37.156	11.74	84.5	4.0	174
USH7	16431	8092	35.523	11.39	84.7	8.0	179
463H11	(563H0x550)x663	7699	33.737	11.41	86.2	9.0	170
463H12	(563H0x546)x663	7672	35.096	10.93	85.4	6.0	174
463H8	(562H0x546)x663	7531	32.630	11.54	84.6	8.0	186
F64-425H4	569H3x3425T	7079	34.001	10.41	82.6	3.0	172
USH8	15517	7036	32.602	10.79	85.5	6.0	170
4539H12	(563H0x546)xNB7	5689	29.567	9.62	83.4	5.0	166
Gen. Mean		7705	33.565	11.47	85.5	7.0	176
SE Mean		399A/	1.482	.31	.89		
LSD (5%)		1114	4.142	.87	2.48		
SEM/Gen. Mean (%)		5.18	4.42	2.70	1.04		

VARIANCE TABLE

Variation Due to	Degrees of Freedom	Mean Square		
		Tons Beets	Percent Sucrose	Percent Purity
Variety	24	53.083	4.053	15.703
Replication	7	90.360	13.483	21.831
Error	168	17.579	.770	6.280
Total	199			
Calc. F. Value		3.020**	5.265**	2.50**
**Exceeds 1% level 1.91				
A/ Short Cut Formula				

Plot Size: 2 rows (30") x 53' Planted
2 rows x 50' Harvested

Design: 5 x 5 Triple Lattice - 9 reps analyzed as a randomized block

Planted: October 25, 1966

Harvested: September 11, 1967

Harvest: Yield - entire plot; Sucrose - 2-25 lb. samples per plot.

Remarks: Reps 8 and 9 were flooded in the spring and rep 9 was under water at harvest. Some bolting and leaf spot was evident. In general this not a good test since it suffered from lack of uniform soil and cultural practices.

Extracted from a test of 25 varieties

VARIETY TEST, EL CENTRO, CALIFORNIA, 1966-67

Grower and location: Jack Shaw, El Centro, California.

Soil type: Holtville silty clay.

Previous crops: Alfalfa, 1964 and 1965; cantaloupe, 1966.

Fertilizer used: 44 lbs. per acre phosphorus, actual, preplant.
80 lbs. per acre nitrogen, actual, preplant.
170 lbs. per acre nitrogen, actual, sidedress.

Planting date: October 15, 1966.

Thinning date: November 17, 1966.

Harvest date: June 3, 1966.

Irrigation: Eight by furrow.

Diseases and insects: Diseases were of minor importance in the field containing the test. Thimet five percent granules were applied in January, 1967 for control of green peach aphid.

Experimental design: Eight varieties planted in an 8 x 8 latin square. Varieties planted on double-row beds with 40-inch centers. Plots 60 feet long.

Sugar analysis: From two ten-beet samples per plot by Union Sugar Division, Imperial Valley Tare Laboratory, El Centro, California.

Remarks: The high sucrose percentages in the test reflected the very dry condition of the plot at harvest. Seed for the test was furnished, the test designed and the results analyzed by the United States Agricultural Research Station, Salinas, California. Plot planted, observed throughout season and harvested by K. D. Beatty, Southwestern Irrigation Field Station, Brawley, California, in cooperation with Union Sugar Division.

VARIETY TEST, EL CENTRO, CALIFORNIA, 1967

(8 replications of each variety)

By Union Sugar Division

Variety	Description	Acre Yield		Sucrose Percent	Harvest Count Number
		Sugar Pounds	Beets Tons		
F66-13H11	(563H0 x 550) x 13	10,420	26.45	19.7	136
F66-13H4	(562H0 x 569) x 13	10,080	25.93	19.4	131
464H11	(563H0 x 550) x 64	9,660	24.99	19.3	133
463H2	(MS of NB1 x NB5) x 63	9,050	23.24	19.5	138
463H8	(562H0 x 546) x 63	8,990	22.95	19.6	141
4539H3	(562H0 x 546) x NB7	8,790	22.05	19.9	138
463H4	(562H0 x 569) x 63	8,720	22.49	19.4	139
4539H4	(562H0 x 569) x NB7	8,540	21.57	19.8	142
General MEAN of all varieties		9,280	23.71	19.6	Beets
S. E. of MEAN		151	0.42	0.12	per
Significant Difference (19:1)		433	1.20	0.34	100'
Coefficient of Variation (%)		4.61	4.99	1.70	row

Odds 19:1 = 2.021 x $\sqrt{2}$ x Standard Error of MEAN

VARIANCE TABLE

Variation due to	Degrees of Freedom	M E A N S Q U A R E S		
		Gross Sugar	Tons Beets	Percent Sucrose
Between varieties	7	3,785,523	27.09	0.36
Between replications	7	1,163,743	6.61	0.60
Between columns	7	876,276	6.31	0.10
Remainder (Error)	42	183,283	1.40	0.11
Total	63			
Calculated F value		20.65**	19.35**	3.24**

** Exceeds the 1% point of significance (F=3.10)

VARIETY TEST, SALINAS, CALIFORNIA, 1967

Grower and location: Elmer Abeloe, Salinas, California.

Soil type: Sandy loam.

Previous crops: Beans, 1965 and 1966; sugarbeets, 1964.

Fertilizer used: 250 lbs. per acre 21:53:0, preplant.
200 lbs. per acre 27:14:0, first sidedress.
600 lbs. per acre 20:0:0 (aqua ammonia) second sidedress.

Planting date: February 16, 1967.

Thinning date: April 20, 1967.

Harvest date: October 18-19, 1967.

Irrigations: Sprinkler irrigated on a 16-day schedule starting about May 20, 1967.

Diseases and insects: Symptoms of a moderate yellows virus infection in the field containing the test were evident by early July, 1967. One spray application with Meta-systox R was made about May 10, 1967 for control of green peach aphid. Moderate nematode infestations were scattered throughout the test area of the field.

Experimental design: Twelve varieties were planted in a randomized block with ten replications. Varieties planted on double-row beds with 40-inch centers. Plots 60 feet long.

Sugar analysis: From two samples per plot, of approximately ten roots each, at the sugar analytical laboratory, United States Agricultural Research Station, Salinas, California.

Remarks: Seed for the test was furnished, the test designed and the results analyzed by the United States Agricultural Research Station, Salinas, California. Test plot conducted in cooperation with Union Sugar Division.

VARIETY TEST, SALINAS, CALIFORNIA, 1967

(10 replications of each variety)
(Two-row plots)

Variety	Description	Acre Yield		Sucrose Percent	N PPM	Na PPM	K PPM	By Union Sugar Division		
		Sugar Pounds	Beets Tons					Imp. Index	T. J. Purity Percent	Harvest Count
630TH22	(563H0 x 753) x 30 (Tetra)	7,650	23.75	16.2	714	582	1,182	809	94.3	136
613H4	(562H0 x 569) x 13 sel.	7,530	23.20	16.3	764	468	1,589	811	94.1	141
F66-13H4	(562H0 x 569) x 13	7,140	22.89	15.6	652	439	1,381	736	94.8	155
613H24	(563H0 x 760) x 13 sel.	7,120	22.41	15.9	726	337	1,465	757	94.6	136
F66-13H11	(563H0 x 550) x 13	6,950	22.78	15.3	636	570	1,344	768	94.7	151
664H8	(562H0 x 546) x 64	6,940	21.12	16.5	641	478	1,422	706	94.7	143
463H11	(563H0 x 550) x 63	6,910	21.98	15.8	601	599	1,306	718	95.2	143
613H29	(563H0 x 754) x 13 sel.	6,830	21.77	15.7	642	445	1,501	742	94.8	142
664H4	(562H0 x 569) x 64	6,650	20.26	16.5	696	581	1,513	772	94.7	154
664H2	(MS of NBL x NB5) x 64	6,600	20.24	16.3	703	481	1,300	731	94.7	141
6403H11	(563H0 x 550) x 403 (Tetra)	6,500	20.16	16.1	679	607	1,218	742	94.8	143
6539H4	(562H0 x 569) x NB7	5,850	19.42	15.1	700	790	1,101	827	94.5	132
General MEAN of all varieties										
Significant Difference (19:1)		6,890	21.7	15.9	679	532	1,393	760	94.6	Beets
Coefficient of Variation (%)		753	2.5	0.8	NS	162	123	NS	NS	per
Calculated F value		12.3	12.9	5.9	16.9	34.3	10.0	12.8	0.8	100'
		3.1**	2.5**	2.4*	NS	4.0**	11.3**	NS	NS	row

* Exceeds the 5% point of significance (F=1.88)

** Exceeds the 1% point of significance (F=2.43)

Beets
per
100'
row

VARIETY TEST, SOLEDAD, CALIFORNIA, 1967

Grower and location: Valley Packing Company, Alfred Bassetti, Dowd Ranch, Soledad, California.

Soil type: Sandy.

Previous crops: Green onions and lettuce, 1966; carrots, 1965; beans, 1964.

Fertilizer used: 400 lbs. per acre 19:9:0, preplant.
400 lbs. per acre 19:9:0, first sidedress.
300 lbs. per acre ammonium sulfate, second sidedress.

Planting date: February 10, 1967.

Thinning date: March 17, 1967.

Harvest date: October 30, 1967.

Irrigation: Ten by furrow.

Diseases and insects: Of no importance in field containing test.

Experimental design: Eight varieties planted in an 8 x 8 latin square. Varieties planted on double-row beds with 40-inch centers. Plots 60 feet long.

Sugar analysis: From two samples per plot, of approximately ten roots each by Union Sugar Division, Betteravia, California.

Remarks: Seed for the test was furnished, the test designed and the results analyzed by the United States Agricultural Research Station, Salinas, California.

VARIETY TEST, SOLEDAD, CALIFORNIA, 1967

(8 x 8 Latin Square)
(Two-row plots)

Variety	Description	Acre Yield		By Union Sugar Division	
		Sugar Pounds	Beets Tons	T. J. Purity Percent	Harvest Count Number
F66-13H11	(563H0 x 550) x 13	8,850	37.31	89.1	136
463H11	(563H0 x 550) x 63	8,580	34.62	89.2	128
F66-13H4	(562H0 x 569) x 13	8,350	34.18	89.3	135
6539H4	(562H0 x 569) x NB7	8,020	34.59	88.5	131
664H2	(MS of NB1 x NB5) x 64	7,820	31.76	88.4	126
664H8	(562H0 x 546) x 64	7,480	30.34	89.3	127
664H4	(562H0 x 569) x 64	7,260	30.89	87.8	146
6403H11	(563H0 x 550) x 403	6,150	28.44	87.4	119
General MEAN of					
all varieties		7,810	32.77	11.9	Beets
Significant Difference (19:1)		581	1.95	0.60	per
Coefficient of Variation (%)		7.41	5.93	5.05	100'
Calculated F value		17.58**	17.70**	6.50**	row
				3.07*	

* Exceeds the 5% point of significance (F=2.24)

** Exceeds the 1% point of significance (F=3.10)

VARIETY TEST, SAN LUCAS, CALIFORNIA, 1967

Grower and location: Mesa Farms No. 2, San Lucas, California.

Soil type: Salinas clay loam.

Previous crops: Sugarbeets, 1964; beans, 1965; bell peppers, 1966.

Fertilizer used: 400 lbs. per acre 15:8:0 preplant.
100 lbs. nitrogen (actual) as 20% Aqua ammonia,
sidedressed.
80 lbs. nitrogen (actual) as 20% Aqua ammonia,
in two applications through sprinkler irrigation
system.

Planting date: February 13, 1967.

Thinning date: March 25, 1967.

Harvest date: October 26, 1967.

Irrigation: Ten with sprinkler system.

Diseases and insects: A moderately severe leaf spot infection,
primarily Cercospora beticola, occurred in the field containing
the test. Virus yellows was not a factor. Leaf miner caused
minor damage.

Experimental design: Ten varieties planted in a 10 x 10 latin
square. Varieties planted on double-row beds with 40-inch
centers. Plots 60 feet long.

Sugar analysis: From two ten-beet samples per plot by Union Sugar
Division, Betteravia, California.

Remarks: Seed for the test plot was furnished, the test designed
and the results analyzed by the United States Agricultural
Research Station, Salinas, California.

VARIETY TEST, SAN LUCAS, CALIFORNIA, 1967

(10 x 10 Latin Square)
(Two-row plots)

Variety		Description	Acre Yield		By Union Sugar Division		Harvest Count
			Sugar Pounds	Beets Tons	Sucrose Percent	T. J. Purity Percent	
F66-13H11	(563H0 x 550) x 13	8,190	33.82	12.1	86.7	149	
F66-13H4	(562H0 x 569) x 13	7,940	32.30	12.3	87.3	154	
463H11	(563H0 x 550) x 63	7,790	30.91	12.6	87.6	150	
664H8	(562H0 x 546) x 64	7,530	29.44	12.8	87.1	157	
6403H11	(563H0 x 550) x 403 (Tetra)	7,470	30.11	12.4	86.5	136	
664H14	(563H0 x 534) x 64	7,430	29.17	12.8	86.5	155	
6403H15	(562H0 x 648) x 403 (Tetra)	7,240	28.68	12.6	86.7	130	
664H4	(562H0 x 569) x 64	7,070	28.45	12.4	85.7	157	
664H2	(MS of NB1 x NB5) x 64	6,920	27.02	12.8	86.9	144	
6539H4	(562H0 x 569) x NB7	6,620	28.35	11.7	86.4	139	
General MEAN of all varieties							
Significant Difference (19:1)		7,420	29.83	12.5	86.7	Beets per 100' row	
Coefficient of Variation (%)		525	1.72	0.46	NS		
Calculated F value		7.93	6.47	4.15	1.73		
		6.60**	11.09**	4.64**	NS		

** Exceeds the 1% point of significance (F=2.67)

VARIETY TEST, KING CITY, CALIFORNIA, 1967

Grower and location: A. S. Duarte, King City, California.

Soil type: Sandy loam.

Previous crops: Tomatoes, 1964; barley, 1965; beans, 1966.

Fertilizer used: 300 lbs. per acre 16:20:0, preplant.
700 lbs. per acre ammonium sulfate in two sidedress applications.

Planting date: February 21, 1967.

Thinning date: March 30, 1967.

Harvest date: October 23-24, 1967.

Irrigation: Six by furrow.

Diseases and insects: Virus yellows was not a factor in the field containing the test. Light infestations of nematode and leaf miner occurred in the test.

Experimental design: Ten varieties planted in a 10 x 10 latin square. Varieties planted on double-row beds with 40-inch centers. Plots 60 feet long.

Sugar analysis: From two ten-beet samples per plot by Union Sugar Division, Betteravia, California.

Remarks: Seed for the test was furnished, the test designed and the results analyzed by the United States Agricultural Research Station, Salinas, California.

VARIETY TEST, KING CITY, CALIFORNIA, 1967

(10 x 10 Latin Square)
(Two-row plots)

Variety	Description	By Union Sugar Division			
		Acre Yield		T. J.	
		Sugar Pounds	Beets Tons	Sucrose Percent	Purity Percent
F66-13H11	(563H0 x 550) x 13	7,960	27.10	14.7	90.0
F66-13H4	(562H0 x 569) x 13	7,440	24.85	15.0	90.3
664H8	(562H0 x 546) x 64	7,380	23.73	15.5	90.7
664H14	(563H0 x 534) x 64	7,330	23.91	15.3	90.2
463H11	(563H0 x 550) x 63	7,020	23.57	14.9	89.8
664H2	(MS of NBL x NB5) x 64	7,010	23.34	15.0	90.5
664H4	(562H0 x 569) x 64	6,860	22.51	15.3	90.4
6403H15	(562H0 x 648) x 403 (Tetra)	6,210	21.56	14.4	89.6
6539H4	(562H0 x 569) x NB7	6,160	21.87	14.1	90.6
6403H11	(563H0 x 550) x 403 (Tetra)	6,140	21.71	14.2	88.5
General MEAN of all varieties		6,950	23.42	14.8	90.0
Significant Difference (19:1)		366	1.12	0.48	0.94
Coefficient of Variation (%)		5.91	5.36	3.65	1.18
Calculated F value		22.70**	18.02**	8.44**	3.84**

Beets
per
100'
row

** Exceeds the 1% point of significance (F=2.67)

DEVELOPMENT OF TRIPLOID AND TETRAPLOID SUGARBEETS

B. L. Hammond

Seed increases of the following tetraploid selections were made at Salinas in 1967 from stecklings grown in Oregon in the winter of 1966-67: 613T, 6704T, 6716T; 6753T; 6757Trr; 6757TR-; 6534T; 6764Trr; 6764TR-; 6546-36T; 6152T(871 x 8539)T; 6153T(F62-63rr x 586R-)T; and 6154T(271rr x 586R-)T. Seed increases are also being made of 686Trr, 686TR-, 664T, 6515T, 630T, and 6559-1T. Seed for these increases was planted in Oregon in August 1966 to produce stecklings for isolation at Salinas in March 1967.

Germinating seed of 234, a self-sterile, yellows-resistant selection obtained from Dr. Rietberg was colchicine-treated and planted in November 1964. Sixty-five promising chimeras were selected for thermal induction in August 1965. Plants were removed from the coldroom in June 1966 and interpollinated. C₁ seed was planted in February 1968 to obtain thermally-induced tetraploids for an additional seed increase in isolation in the fall of 1968. This selection has both green and red hypocotyls.

Pregerminated seed of the monogerm inbred 4806 from F57-85 was colchicine-treated and planted in May 1965. One-hundred fifty-five seedlings were transplanted to pots in June 1965. Sixty-eight good chimeras were placed under thermal induction in September 1965. Plants were removed in March 1966 and interpollinated. C₁ seed was planted in February 1968 to obtain thermally-induced tetraploids for an additional seed increase in isolation in the fall of 1968. This selection has green hypocotyls.

One-hundred fifty colchicine-treated seedlings of selection 4742 were transplanted to pots in August 1965. Seventy plants were selected for thermal induction in October. Plants were removed in May 1966 and interpollinated. C₁ seed was planted in February 1968 to obtain thermally-induced tetraploids for an additional seed increase in isolation in the fall of 1968. This multigerm inbred has red hypocotyls and is yellows resistant.

In June 1965, pregerminated seed of selection F60-512 was colchicine-treated. One-hundred fifty seedlings were potted in September. Seventy plants were placed under thermal induction in January 1966 and removed in September for interpollinating in September. C₁ seed was planted in March 1967 for seed increase. This is a bolting-resistant, multigerm inbred.

Germinating seed of 4754, a yellows-resistant, multigerm inbred-selection, was colchicine-treated in August 1965 and transplanted to pots in November. These were placed in the coldroom for thermal induction in February 1966 and removed in August for selfing.

In January 1966, pregerminated seed of selection 3646-32-5 was colchicine-treated. One-hundred fifty seedlings were potted in April, of which 66 of the best chimeras were placed under thermal induction in September 1966. The C_1 seed obtained from this selection was planted in February 1968 to obtain thermally-induced tetraploids for a seed increase in isolation in the fall of 1968.

Germinating seed of 537A, a self-sterile multigerm, was colchicine-treated in April 1966. One-hundred fifty of these were potted in June, of which 61 (53 with red hypocotyls and 8 with green) were placed in the coldroom in September for thermal induction. The C_1 seed obtained from this selection was planted in February 1968 to obtain thermally-induced tetraploids for a seed increase in isolation in the fall of 1968.

In June 1966, germinated seedlings of 544 were colchicine-treated. Seventy-five each of green and red hypocotyls were potted in November. The C_1 seed obtained from this selection was planted in February 1968 to obtain thermally-induced tetraploids for a seed increase in isolation in the fall of 1968. This is a yellows-resistant, self-sterile multigerm obtained from Dr. Rietberg.

Seedlings of selection 4522, a self-fertile, monogerm inbred, were colchicine-treated and planted in August 1966. One-hundred fifty selected plants were potted in November. These were placed under thermal induction in February 1967 and removed in November for pollinating.

Germinating seedlings of 5703 were colchicine-treated and planted in September 1966. This is a self-fertile, multigerm inbred. One-hundred fifty selected plants were potted in November. They were placed in the coldroom in March 1967 and removed in December for pollinating.

In November 1966, germinating seedlings of 5633 were colchicine-treated and planted. This is a self-fertile, monogerm inbred selection. One-hundred fifty selected plants were potted in January 1967. These were placed under thermal induction in April and removed in March 1968 for pollinating.

Seedlings of 5601-5-3, a curly-top resistant monogerm inbred selection, was colchicine-treated in November 1966 and transplanted to pots in January 1967. On the basis of cytological examination, the best chimeras were selected for thermal induction in March and removed from the coldroom in August for pollinating. C_1 seed was planted in February to obtain thermally-induced tetraploids for seed increase in isolation in the fall of 1968.

Colchicine-treated seedlings of 6705 were planted in November 1966. This is a yellows-resistant, monogerm inbred. It is close to type 0 and will be used in crosses with the male-sterile selection, 6705H24. Plants were removed from thermal induction in March 1968 for crossing.

Germinating seed of 6705H24 was colchicine-treated in November 1966. This is a yellows-resistant, male-sterile equivalent of 6705 described above and will be used to produce a male-sterile tetraploid line. These plants were removed from the coldroom in March 1968 for crossing.

In July 1967, germinating seed of selection 7832-1 was colchicine-treated. One-hundred fifty seedlings were potted in September. Thirty-four of the most promising chimeras were placed under thermal induction in February 1968. This is a monogerm inbred and yellows resistant.

Germinating seed of 713A, a multigerm composite selected from US 75 for yellows resistance, was colchicine-treated in August 1967. One-hundred fifty seedlings were transplanted to pots in November. Sixty-eight of these were placed in the coldroom in December.

One-hundred fifty colchicine-treated seedlings of selection 5760 were transplanted to pots in November. Fifty-seven were selected for thermal induction in January. This selection is a yellows-resistant multigerm.

In September 1967, germinating seed of the yellows-resistant monogerm inbred selection 7718 was colchicine-treated. One-hundred fifty seedlings were potted, from which 59 were selected for thermal induction in February 1968.

Seedlings of selection 7751, a yellows-resistant monogerm inbred, were colchicine-treated in October 1967. From 150 plants transplanted to pots in December, 41 were selected for thermal induction in February 1968 on the basis of cytological examinations.

Germinating seed of selection 6722 was colchicine-treated in October. One-hundred fifty seedlings were potted in December, from which 69 were selected for thermal induction in February 1968. This selection is a monogerm inbred and yellows resistant.

In October 1967, germinating seed of selection 6707 was colchicine-treated. One-hundred fifty seedlings were potted in December. Of these, 69 promising chimeras were placed in the coldroom in February 1968. This is a monogerm inbred and yellows resistant.

Y603 is a yellows-resistant multigerm composite obtained from Dr. Rietberg. Germinating seed was colchicine-treated and planted in January 1967.

PROGRESS IN BREEDING FOR YELLOWS RESISTANCE^{1/}

Lewellen, R. T., McFarlane, J. S., and Skoyen, I. O.

Since 1962 sugarbeet lines from the virus-yellows resistance breeding project at Salinas, California, have been evaluated for resistance at Davis, California. Evaluation for yellows resistance was continued in 1967 with a program transition from J. S. McFarlane to R. T. Lewellen.

Plans and Procedures

Three evaluation tests were planted at Davis in 1967. Because of cool spring conditions, planting was delayed later than usual until flights of the green peach aphid, Myzus persicae, had ceased. The tests were planted May 23 in a dry seedbed and were irrigated two weeks later.

In the first test, 11 self-sterile lines were evaluated. US 75 (F57-68) was included as a susceptible check and as the source population from which several of the lines were selected. Two lines, FS 4 and FS 7, selected on the basis of root size and amino acid ratio from Dr. J. M. Fife's program were included.

In the second test, 10 hybrids using one or more components from the yellows-resistance program were evaluated. US H7 was included as a check.

In the third test, inbreds selected for yellows resistance were evaluated.

Each test was planted as a randomized-block design with 5 replications. Each replication was then subdivided into split blocks with inoculated and noninoculated treatments. Subplots were 2-rows wide on 30 inch centers and 42 feet long. The plots were inoculated July 20 with a combination of a virulent strain (7) of beet yellows virus (BYV) and a strain (3) of beet western yellows virus (BWYV) of unknown virulence. The plots were harvested October 23-25. Field weights were taken and two samples were collected from each subplot for sugar analysis. From the lead acetate filtrate from each sugar analysis, amino nitrogen, sodium, and potassium concentrations were determined.

^{1/} The assistance of Dr. F. J. Hills of the University of California in arranging and caring for the tests is gratefully acknowledged.

As a measure of resistance, the percent yield loss was determined for each pair of inoculated and noninoculated subplots.

Results and Discussion

Between thinning and inoculating, certain plots were partially destroyed by cultivation. The missing feet of row were measured and plant counts made. Subplots within each replication were then adjusted by equalizing plant stand and missing feet of row. After harvest the root yields for damaged plots were adjusted to whole plot values. Because compensation for the missing space was difficult to determine and all entries were not affected equally, the yield data may be somewhat biased. However, because inoculated and noninoculated subplots were grown under similar conditions, the calculated percent loss due to yellows should be accurate. The data for the other characters was probably only slightly influenced.

The inoculated strips showed a high infection percentage with little spread of yellows into the noninoculated strips.

The results for the open-pollinated lines are shown in Table 1. Yield losses ranged from 21.0% for 613A to 42.7% for US 75. The 613A line represents the 7th yellows-resistant selection out of US 75 on the basis of freedom from yellowing and root size in infected populations. In addition the last selection was based on sucrose percentage. The 613B line was not selected for sucrose percentage and showed just slightly higher root weight and lower sucrose percentage. Both 613 lines performed similar to US 75 when noninfected but are significantly better for both root yield and sucrose percentage when diseased with yellows.

A new line showing good promise for yield and resistance is 610. This line is the increase of crosses made between a self-sterile, Type O line selected for yellows resistance and a self-sterile, resistant line from the Netherlands. The 544 line continued to show promising results. Both lines will be low in curly top resistance, however, due to their susceptible European parent.

The F64-30, 630, and 630T lines were intermediate in resistance. The two selections based on an amino acid ratio and root weight, FS 4 and FS 7, were not significantly different in resistance from US 75 from which they were selected.

Sucrose losses varied from 0.3 to 1.5 percentage points. Sucrose losses, however, have not proven to be as good an indication of resistance as root weight losses.

Table 2 gives the results of experimental hybrids which used one or more lines selected for yellows resistance. Yield losses varied from 23.3% for 630TH22 to 36.0% for 5760H4. US H7 (464H4), which has no resistant component, had a 43.1% loss. Sucrose showed from 0.3 percentage point increase for the inoculated to 0.9 percentage point decrease, and in general yellows appeared to have little influence on sucrose percentage.

Five of the experimental hybrids had the self-sterile 13 line as a topcross parent. These hybrids showed losses from 30.7 to 33.6%. As previously shown, the 13 line lost approximately 22%. Vigorous varieties or lines that are not selected for yellows resistance undergo about a 43% loss due to yellows, e.g., US 75 or 464H4. The hybrid with the 13 line crossed with a susceptible seed parent then showed losses just half way between these extremes or indicating that resistance is inherited in an additive manner.

The hybrid which showed the highest resistance was a triploid, 630TH22, in which two genomes came from a tetraploid, yellows-resistant, topcross parent and a single genome came from the single-cross, seed parent. In addition the Type 0 pollinator of the seed parent was also selected for yellows resistance.

Two single-cross hybrids, 4716H3 and 5760H4, with the pollen parents being yellows-resistant inbreds showed slightly greater yield loss than the three way hybrids with the 13 line. Three of the hybrids had two of their components from yellows-resistant material, but showed similar losses as the 13 hybrids. Apparently we have yet to find good combinations between these selections to give increased resistance.

There was not a significant difference between the hybrids for beet yield under either infection treatment. This may reflect the short season used at Davis in which rapid growth is occurring for all varieties and which may not allow enough time for differentiation to occur between different genotypes. The Davis test was not an adequate test of hybrid combinations for testing yields.

Table 3 gives the results for the inbred test. Differences in yield loss were not significant but showed losses varying from 35.2% to 48.7%. Sucrose showed losses from 0.7 to 2.2 percentage points.

The multigerm inbred 5760 showed the best resistance. Inbred 6705 was the best appearing monogerm. In addition to its resistance, 6705 has the highest sucrose percentage in the noninoculated test.

Table 1. Reduction in yield and performance of self-sterile sugarbeet lines under BYV-BMYV inoculated and noninoculated treatments at Davis, California, in 1967.

No.	Description	Tons Roots/A		Yield Loss		Sucrose %	
		Check	Inoc.	Check	%	Check	Inoc.
610	YRS(321 x 234)	26.4	19.0	27.8		12.6	11.8
630T	Tetra 30	25.8	18.2	29.4		13.1	12.6
544	Increase (330 x 234)	24.5	19.1	22.2		13.4	12.9
FS4	Fife YRS US 75	23.9	14.5	39.2		13.2	12.0
Y603	YRS 34	23.4	17.9	23.0		14.7	13.8
F64-30	YRS US 75	23.2	16.4	29.3		13.0	12.7
613B	7th YRS US 75	22.4	17.3	22.5		12.9	12.5
613A	YRS, sucrose sel. US 75	22.3	17.7	21.0		13.4	12.7
630	YRS 30	22.3	15.9	28.3		13.4	13.0
F57-68	US 75	22.1	12.5	42.7		13.1	11.7
FS7	Fife YRS US 75	21.7	14.0	35.7		14.5	13.0
LSD (5%)		2.60	1.91	8.28		0.86	0.55
No.	NH ₄ -N ppm	Na ppm		K ppm		Impur. Index	
		Check	Inoc.	Check	Inoc.	Check	Inoc.
610	645	1242	1291	2828	2902	1418	1607
630T	839	609	698	2958	2967	1368	1501
544	694	623	679	3107	3089	1260	1334
FS4	1209	568	669	3359	3144	1703	2361
Y603	687	494	633	2930	2788	1083	1171
F64-30	845	499	604	3236	3176	1407	1429
613B	654	432	433	3482	3507	1299	1348
613A	677	360	491	3408	3537	1235	1390
630	817	497	482	3396	3507	1373	1463
F57-68	870	700	871	3199	3187	1462	1870
FS7	901	421	549	3035	2942	1246	1657
LSD (5%)	158	261	231	208	237	--	--

Table 2. Reduction in yield and performance of sugarbeet hybrids under BYV-BWV inoculated and noninoculated treatments at Davis, California, in 1967.

No.	Description	Tons Roots/A		Yield Loss %		Sucrose %	
		Check	Inoc.	Check	Inoc.	Check	Inoc.
613H27T	562H5T x 13 sel.	28.5	19.8	29.8	12.3	12.0	
630TH22	(563H0 x 753) x 30 (Tetra)	26.2	19.8	23.3	12.5	12.0	
413H8	(562H0 x 546) x 13	28.2	19.0	32.8	12.6	12.2	
613H24	(563H0 x 760) x 13 sel.	28.1	18.8	32.5	12.7	12.7	
F66-13H4	(562H0 x 569) x 13	26.9	18.7	30.7	12.6	12.9	
4716H3	562H0 x 716	27.8	18.5	33.5	12.6	11.7	
613H4	(562H0 x 569) x 13 sel.	26.4	18.3	30.9	12.9	12.6	
613H29	(563H0 x 754) x 13 sel.	26.8	17.4	33.6	12.4	12.5	
5760H4	563H0 x 760	28.1	17.7	36.0	13.3	13.0	
6705H24	(563H0 x 760) x 705	24.3	17.0	29.7	13.8	13.5	
464H4	(562H0 x 569) x 64	27.6	15.7	43.1	12.8	12.8	
LSD (5%)		NS	NS	8.8	0.6	0.7	

No.	NH ₄ -N ppm		Na ppm		K ppm		Impur. Index	
	Check	Inoc.	Check	Inoc.	Check	Inoc.	Check	Inoc.
613H27T	723	752	957	751	3254	3353	1522	1544
630TH22	978	961	1071	942	3125	3176	1707	1737
413H8	769	875	744	740	3310	3396	1474	1625
613H24	915	908	640	417	3374	3501	1561	1519
F66-13H4	844	984	752	454	3371	3384	1548	1542
4716H3	936	910	781	819	3255	3347	1606	1738
613H4	764	782	642	414	3374	3525	1420	1435
613H29	846	883	754	623	3390	3365	1579	1554
5760H4	993	1202	539	357	2875	3125	1429	1622
6705H24	862	912	660	361	2894	2913	1316	1309
464H4	931	993	843	588	3414	3414	1625	1603
LSD (5%)	159	220	242	274	213	245	--	--

Table 3. Reduction in yield and performance of sugarbeet inbreds under BYV-BWV inoculated and noninoculated treatments at Davis, California, in 1967.

No.	Description	Tons Roots/A		Yield Loss %		Sucrose %	
		Check	Inoc.	Check	Inoc.	Check	Inoc.
5760	YRS(911 x 717)	19.4	12.6	35.2	13.4	12.7	12.7
4716-18B	YRS 7628-24	17.8	11.1	37.6	12.4	10.8	10.8
6739	Inc(121 x 711)	17.7	10.0	43.4	12.9	10.7	10.7
5754B	YRS(671 x 716)	17.4	9.7	43.5	12.2	11.5	11.5
6705	Inc(121 x 743)	15.1	9.4	37.4	14.7	13.4	13.4
6707	Inc(121 x 550)	16.5	9.1	44.4	13.7	12.7	12.7
6757	YRS(911 x 716)	14.2	8.7	39.0	12.2	11.4	11.4
6718	Inc(563 x 716)	15.2	7.8	48.7	13.6	11.4	11.4
6722	Inc(330 x 563)	13.2	7.2	45.4	12.8	12.0	12.0
5715	YRS(mm aa x 561)	12.0	7.2	40.9	14.5	13.8	13.8
6702	YRS(121 x 563)	11.2	5.7	48.4	13.8	12.2	12.2
6714	Inc(563 x 743)	9.9	5.1	48.1	14.3	12.5	12.5
LSD (5%)		2.99	2.14	NS	0.86	0.81	0.81

No.	NH ₄ -N ppm		Na ppm		K ppm		Impur. Index	
	Check	Inoc.	Check	Inoc.	Check	Inoc.	Check	Inoc.
5760	1462	1227	482	662	3119	2975	1799	1734
4716-18B	820	805	1248	1599	3421	3267	1703	2020
6739	1077	1726	1333	1978	2794	2592	1738	2866
5754B	1962	1384	773	999	3531	3440	2554	2255
6705	1115	1366	551	876	2606	2495	1333	1714
6707	604	822	1026	1061	3052	3126	1260	1555
6757	1427	1035	714	1051	3716	3636	2136	2028
6718	1498	3743	252	395	3821	3987	1869	4279
6722	1866	3466	521	478	3292	3476	2243	3752
5715	751	748	633	669	2500	2229	1102	1116
6702	2170	4011	703	648	2997	3224	2294	4134
6714	2844	4625	271	337	3025	2963	2584	4387
LSD (5%)	893	1577	266	383	374	355	--	--

The inbreds did not perform well at Davis. The yield losses for the best inbreds ranked with the susceptible self-sterile lines. In general there were poor stands and the hot summer temperatures caused low vigor. They were also more severely damaged by yellows under these conditions. The vigor of the inbreds appeared to be associated with yield loss. The best yielding, most vigorous ones showed the least damage.

Impurity indices were computed for the inoculated and noninoculated treatments of each test. Usually the impurity index for a particular entry increased from the noninoculated to inoculated treatments. The amino nitrogen ($\text{NH}_2\text{-N}$), sodium, and potassium concentrations used to compute these indices will be presented separately.

For amino nitrogen, the infected, self-sterile lines and hybrids showed higher concentrations than the healthy checks. The inbreds showed both increases and decreases from one entry to the next. It was observed in the open-pollinated test that the more resistant lines were lower in amino nitrogen content than the susceptible lines and that the susceptible lines showed greater increases due to infection. For example, the 613 lines did not appreciably change while US 75 showed a 200 ppm increase.

The hybrids were more uniform than the self-sterile lines within treatments and changed less between treatments. The hybrids with the 13 line were 200 to 300 ppm higher than the 13 line itself. This difference suggested that the seed-bearing parent was contributing to the higher amino nitrogen level.

The patterns produced by the inbreds were more variable within and between treatments. In addition, some inbreds showed much higher concentrations than either the open-pollinated or hybrid lines.

The sodium concentrations varied from 360 to 1242 ppm for the noninoculated, open-pollinated entries. Most lines fell within the 400 to 700 ppm range with line 610 showing nearly twice the sodium content of the other lines. Most of these lines increased by about 100 ppm when infected, but 613B increased just 1 ppm and 613A decreased slightly. Susceptible US 75 was higher than any of the yellows-resistant selections made from it, e.g., 613 and 630.

The inbreds were also more variable for sodium with concentrations occurring from 252 to 1978 ppm. In general the infected treatment was higher than the healthy check.

Unlike the self-sterile and inbred lines, the noninfected hybrids were higher in sodium than the infected ones. We are unable to explain why this reversal occurred.

The potassium content varied from 2788 to 3537 ppm in the open-pollinated lines. The inoculation treatment did not appear to cause much change with about half of the entries increasing and half decreasing due to infection. Unlike amino nitrogen and sodium, the potassium content of US 75 was lower in concentration than the yellows-resistant selections made from it.

The inbred lines were within the same range as the open-pollinated lines. Again the influence of infection on potassium was questionable with some lines increasing and others decreasing in content. All but one of the hybrids showed slight increases in potassium due to yellows.

The combined effects of amino nitrogen, sodium, and potassium generally caused an entry to have higher impurity values in the infected treatments. In addition, since sucrose percentage was used as a division in computing the impurity index, the increased values partially reflect the decrease in sucrose caused by infection. The influence of yellows, however, for certain tests and entries is questionable and will be examined in future experiments.

ASSOCIATION OF RESISTANCE TO BYV AND BWYV

In conjunction with the three previous tests assaying yellows resistance in sugarbeet lines, a fourth test was grown at Davis in 1967 to determine if resistance to beet yellows virus (BYV) and beet western yellows virus (BWYV) is associated or independent in yellows-resistant lines. We also wanted to determine what portion of the resistance in selected lines is toward each virus.

Over the past 12 years selecting resistance to yellows has involved source populations inoculated with a combination of BYV and BWYV. Because of the natural spread of both viruses in the selection plots, inoculating with a combination of both viruses has given uniform disease conditions and prevented selection of beets that were infected later or with only a single virus. This procedure should have the advantage of putting resistance to both viruses into the same lines. On the other hand, if resistance is not associated, accumulation of resistance factors to a single virus is probably slowed down. In certain cases it may be advantageous to make rapid progress in resistance to a single virus.

Plans and Procedures

Seven lines were chosen for this experiment. Three self-sterile lines selected for yellows resistance were used that represented selections made from divergent source populations. US 75 was included as a check variety. Two inbred lines representing the best multigerm and monogerm selections were used.

A random-block design was used with five replications. Each replication was then randomly divided into equal strips and inoculated with BYV, BWYV, or left as a noninoculated check. Virulent strain 7 of BYV and strain 3 of BWYV were used. Planting and harvesting dates were the same as those previously presented for the Davis tests. However, the plots were inoculated 10 days later on July 31.

Root yield loss percentages were calculated for both BYV and BWYV inoculated subplots in comparison to the noninoculated check.

Results and Discussion

The data for the seven lines are presented in Table 4. Because the inbreds, 6705 and 5760, did not compete well in this test, emphasis will be placed on the four open-pollinated lines. The virulent strain of BYV caused 18.9 to 36.2% beet yield reduction. The BWYV strain used was apparently of low virulence and caused 2.3 to 8.0% reduction in the self-sterile lines. When the yield reductions caused by these viruses are totaled, the sum is nearly identical to that of the BYV-BWYV combination used in the previous tests (see Table 1). These findings agreed with previous results showing that the effects of BYV and BWYV

Table 4. Reduction in yield of BWYV and BYV inoculated
sugarbeet lines at Davis, California, in 1967.

No.	Description	Tons Roots/A			% Yield Loss			Sucrose Percentage		
		Check	BWYV		BWYV	Inoc.	BYV	Check	BWYV	
			Inoc.	Inoc.					Inoc.	Inoc.
Y603	YRS 34	27.4	26.8	22.3	2.3	18.9		14.0	13.9	13.5
613B	7th YRS US 75	27.2	26.4	21.6	3.1	20.7		12.5	12.4	12.4
637	2nd YRS 63	28.7	27.3	21.8	5.0	23.0		12.6	12.9	12.6
F57-68	US 75	22.4	20.6	14.3	8.0	36.2		13.4	13.1	12.9
6705	(12J x 743)mm	13.3	12.8	10.8	4.0	19.1		15.8	15.7	14.3
5760	YRS(911 x 717)M	16.1	13.6	12.7	15.4	21.5		14.1	14.0	13.6
LSD (5%)		2.8	2.6	2.3	--	9.7		1.1	0.8	1.1

are additive. In general BYV caused a greater reduction in sucrose percentage than BWYV.

Y603 showed the greatest resistance to both BYV and BWYV and US 75 showed the greatest susceptibility to both viruses. The rankings of lines 613B (second) and 637 (third) were also the same for both viruses for yield loss percentage. Of the total losses due to yellows, BWYV accounted for 11, 12, 17, and 18% in Y603, 613B, 637, and US 75, respectively.

These preliminary results suggested that there is at least a partial association between resistance to both viruses, and as the resistance to one is increased, the resistance to the other is likewise increased. These results are somewhat surprising. One expects that resistance to different viruses would be inherited and expressed by different factors.

We feel that a more virulent strain of BWYV is necessary in future studies of this nature. A test will be conducted at Davis in 1968 to select a virulent strain. Additional varieties representing a wider range of resistant material will then be tested to determine the association between BYV and BWYV resistance.

EFFECTS OF DATE OF HARVEST AND NITROGEN ON
PERFORMANCE OF TWO YELLOWS INOCULATED SUGAR-
BEET VARIETIES

Tests at Salinas and Davis were grown in 1967 to compare the effects of yellows infection on the moderately resistant 13 selection and its more susceptible parental variety, US 75. A combination of BYV and BWYV was used to inoculate the tests. At Davis inoculated and noninoculated plots were compared. At Salinas the uniformly infected test was grown under two nitrogen levels and harvested at eight dates with two-week intervals starting July 25 and ending October 31. Root yield, sucrose percentage, and $\text{NH}_2\text{-N}$, Na, and K concentrations were measured for all treatments. Petiole- NO_3 levels were measured at Salinas.

Under infected conditions at Salinas, root yield and sucrose percentage increased faster in the 13 line than in the US 75 variety. Line 13 increased in gross sucrose through October 31 whereas US 75 showed no increase after September 19. Decreases in the Na, K, and petiole- NO_3 contents corresponded with the period of rapid growth. However, these constituents increased in concentration as the growth rate decreased in September and October. Amino nitrogen showed little change through the course of the season.

When free from yellows, US 75 and selection 13 were not different for root yield, sucrose percentage, or gross sucrose but were significantly different for Na, $\text{NH}_2\text{-N}$, and K. The Na and $\text{NH}_2\text{-N}$ concentrations were higher and the K content lower for US 75.

When infected, US 75 and selection 13 were significantly different for root yield and sucrose percentage with selection 13 yielding 68% more gross sucrose. Infection with yellows caused no significant change in Na, $\text{NH}_2\text{-N}$, or K levels in selection 13 but caused increased concentration of these impurities in US 75. Resistance in line 13 to yellows was not due to selection for increased vigor or yielding ability but to selection for resistance factors.

The high nitrogen treatment caused increased root yields, decreased sucrose percentages, and increased petiole- NO_3 , Na, and $\text{NH}_2\text{-N}$ contents, but did not influence K significantly. The nitrogen treatments caused greater changes in US 75 than in moderately resistant 13. The nitrogen level did not appear to influence the resistance of line 13.

New Sugarbeet Varieties Reduce Losses from Yellows

J. S. McFarlane and I. O. Skoyen

Two monogerm, hybrid varieties that utilize the yellows resistant selection 413 as the pollen parent have been released for use by the sugarbeet growers. The varieties, designated US H9A and US H9B, were developed at the U. S. Agricultural Research Station in cooperation with Beet Sugar Development Foundation, the California Beet Growers Association, and the University of California. They have been tested during the past three years by the U. S. Department of Agriculture and the California sugar companies.

US H9A has the parentage (562H0 x 569) x 413. The parentage of US H9B is similar except for the substitution of 546 for the 569 inbred. The seed-bearing parent, 562H0 x 569, is an F_1 hybrid between the male sterile equivalent of the 562 inbred and the 569 inbred. The 562 inbred is an increase of an S_2 monogerm line selected for bolting and curly top resistance. The male-sterile equivalent of 562 has been produced by crossing 562 to a cytoplasmic male sterile line and then back-crossing to 562. The 569 inbred is the increase of an S_3 monogerm line and possesses moderate resistance to bolting and curly top. The 546 inbred is an increase of an S_2 monogerm line and possesses good resistance to bolting and curly top. Both F_1 seed-bearing parents have good vigor, bolting resistance, and curly top resistance. They have been used extensively in commercial hybrid varieties and have performed well.

In the testing program, the new hybrids were compared with US H7, a monogerm hybrid variety that is extensively used in California. Yield losses from yellows averaged 27% for US H9A, 28% for US H9B, and 40% for US H7. The bolting resistance of the new hybrids is similar to that of US H7 and is adequate to meet the requirements for early planting in most sugarbeet growing districts of the state. The curly top resistance of the new hybrids is also good and is a little superior to that of US H7. Damage from curly top can take place when the plants are infected in the seedling stage, but the varieties will withstand the attacks occurring in most areas without serious injury. Downy-mildew resistance has not been determined, but is expected to be equal to that of US H7. Sugar factory tests have shown that the juice purities of US H9A and US H9B are equal to the purities of varieties now being grown.

In 17 tests grown under conditions of moderate to severe yellows (table 1), US H9A produced an average 22% more sugar per acre than did US H7. In 11 tests, US H9B produced a 27% higher sugar yield than did US H7. Sucrose averaged 0.3 percentage points higher for the new hybrids than for US H7. Tests under conditions of light yellows infection (table 1) showed an average 15% higher sugar yield and 0.2 percentage points higher sucrose for US H9A than for US H7. Additional tests with US H9A and US H9B were conducted by Spreckels Sugar in the San Joaquin Valley. Comparisons of the performance of the US H9 hybrids with the mean of other varieties included in the tests are shown in table 2.

Comparisons between the US H9 hybrids and US 75 are even more striking. In five tests (table 3), under conditions of moderate to severe yellows, the US H9 hybrids produced 66% more sugar per acre and averaged 0.7 percentage points higher in sucrose than did US 75. These results show the improvement that has been made in sugarbeet varieties during the past 15 years. US 75 was the first variety developed at the U. S. Agricultural Research Station and brought together curly top, bolting, and downy mildew resistance. In addition to producing higher sugar yields, the new hybrids are monogerm, whereas US 75 is multigerm.

The new varieties may be used in all sugarbeet production areas of the state in which virus yellows causes damage. Greatest improvements in yield occur when yellows infection is severe, but the varieties will also perform well under yellows-free conditions. Neither variety has *Cercospora* leaf spot resistance and could be damaged if grown in areas subject to this disease. The two varieties can be used interchangeably. US H9A has been tested more thoroughly than US H9B, but tests show that both varieties are adapted to a wide range of growing conditions.

Seed of the parent lines has been made available to the sugar companies and a limited amount of commercial seed was produced in 1967. Adequate seed should be available for widescale planting in the 1968-69 season.

Table 1. Performance of US H9A and US H9B expressed in percent of the performance of the standard US H7 variety in tests exposed to varying amounts of virus yellows.

Location	Year	Gross Sugar Yield		Percent Sucrose	
		US H9A	US H9B	US H9A	US H9B
<u>Severe yellows</u>					
Salinas (nat. inf.)	1965	116	115	97	103
Salinas (inoc.)	1966	121	132	105	109
Salinas (nat. inf.)	1966	131	139	99	97
Davis (inoc.)	1966	134	136	102	104
Salinas (inoc.)	1967	120	122	102	105
Average		124	129	101	104
<u>Moderate yellows</u>					
Salinas (nat. inf.)	1966	135	121	106	105
Salinas (nat. inf.)	1966	109	114	102	102
Brawley (E. har.)	1966	122	139	101	101
Brawley (L. har.)	1966	135	142	102	104
Salinas (nat. inf.)	1967	107	--	95	--
Salinas (nat. inf.)	1967	111	110	102	99
Brawley (E. har.)	1967	123	124	101	99
Brawley (L. har.)	1967	134	--	105	--
Imperial Val. (1st har.)	1967	120	--	102	--
Imperial Val. (2nd har.)	1967	125	--	102	--
Imperial Val. (3rd har.)	1967	119	--	104	--
Imperial Val. (USDA)	1967	115	--	105	--
Average		121	125	102	102
<u>Light yellows</u>					
King City	1965	122	--	101	--
San Lucas	1965	117	--	104	--
Brawley	1965	117	--	101	--
Davis	1966	111	107	101	98
El Centro	1967	116	--	100	--
King City	1967	108	--	98	--
San Lucas	1967	112	--	99	--
Soledad	1967	115	--	103	--
Imperial Val.	1967	119	--	104	--
Tulare	1967	112	--	105	--
Average		115	107	102	98

Table 2. Summary of 1967 tests with US H9A and US H9B by Spreckels Sugar Company in the San Joaquin Valley of California.

Newton Brothers - Stratford				
Planted 10-25-66			Harvested 8-17-67	
	<u>S/A</u>	<u>T/A</u>	<u>S/%</u>	<u>RANK</u>
US H9A	4.26	26.7	16.0	1
Mean	3.37	21.4	15.7	8
LSD P = .05	0.57	3.6	0.5	
J. B. Hawkins - Five Points				
Planted 10-30-66			Harvested 8-04-67	
	<u>S/A</u>	<u>T/A</u>	<u>S/%</u>	<u>RANK</u>
US H9B	4.75	30.6	15.5	2
Mean	4.42	28.6	15.5	8
LSD P = .05	0.31	1.9	0.5	
J. G. Boswell - Taft				
Planted 12-16-66			Harvested 7-26-67	
	<u>S/A</u>	<u>T/A</u>	<u>S/%</u>	<u>RANK</u>
US H9A	4.42	43.4	10.1	1
Mean	3.93	38.9	10.1	8
LSD P = .05	0.62	5.5	N.S.	
Noel Brothers - Lindsay				
Planted 1-20-67			Harvested 8-30-67	
	<u>S/A</u>	<u>T/A</u>	<u>S/%</u>	<u>RANK</u>
US H9B	4.77	37.9	12.6	2
Mean	4.44	34.5	12.9	8
LSD P = .05	N.S.	N.S.	0.7	
Coalinga School Farm - Coalinga				
Planted 1-20-67			Harvested 8-08-67	
	<u>S/A</u>	<u>T/A</u>	<u>S/%</u>	<u>RANK</u>
US H9B	4.11	24.8	16.6	2
Mean	3.84	23.2	16.6	8
LSD P = .05	0.33	2.1	0.4	

Table 2 (continued)

Spreckels Test #2 - Mendota
Planted 3-03-67

Harvested 10-10-67

	<u>S/A</u>	<u>T/A</u>	<u>S/%</u>	<u>RANK</u>
US H9A	5.69	39.6	14.4	2
US H9B	5.39	38.7	14.0	3
Mean	4.86	35.4	13.8	16
LSD P = .05	0.64	4.0	0.3	

Spreckels Test #4 - Mendota
Planted 3-03-67

Harvested 10-04-67

	<u>S/A</u>	<u>T/A</u>	<u>S/%</u>	<u>RANK</u>
US H9A	5.21	33.3	15.7	1
Mean	4.51	30.2	15.0	16
LSD P = .05	0.66	4.6	1.4	

Spreckels Test #8 - Mendota
Planted 6-01-67

Harvested 10-25-67

(CHECK)	<u>S/A</u>	<u>T/A</u>	<u>S/%</u>	<u>RANK</u>	<u>% C.T. 7/21</u>	<u>% C.T. 10/9</u>
US H9B	4.44	32.7	13.6	1	6.9	13.8
Mean	3.35	24.5	13.8	8	9.5	38.0
(THIMET)						
US H9B	3.98	29.9	13.3	2	1.4	5.1
Mean	3.54	26.8	13.4	8	1.0	14.9
LSD P = .05	0.54	4.3	0.9		7.3	11.2

Table 3. Performance of US H9A, US H9B, and US 75 in five tests grown under conditions of moderate to severe yellows infection.

Location	Year	Variety	Acre Yield		Sucrose Percent
			Sugar	Beets	
			Pounds	Tons	
Salinas (inoc.)	1966	US H9B	8,530	26.30	16.3
		US 75	4,650	16.25	14.3
		L.S.D. (5%)	644	2.12	0.56
Salinas (nat. inf.)	1967	US H9B	10,490	38.04	13.8
		US 75	6,730	25.05	13.5
		L.S.D. (5%)	519	1.93	0.4
Salinas (inoc.)	1967	US H9B	8,450	30.95	13.7
		US 75	4,580	17.80	12.9
		L.S.D. (5%)	529	2.22	0.4
Brawley (E. har.)	1967	US H9A	8,790	31.99	13.8
		US 75	6,290	22.58	14.0
		L.S.D. (5%)	845	2.78	0.6
Brawley (L. har.)	1967	US H9A	9,800	35.71	13.7
		US 75	5,480	20.74	13.2
		L.S.D. (5%)	621	2.26	0.52
Average of US H9A and US H9B			9,212	32.60	14.3
Average of US 75			5,546	20.48	13.6
Performance of US H9A and US H9B in percent of US 75			166	159	105

Evaluation of Selections and Hybrids for Yellows Resistance

J. S. McFarlane, I. O. Skoyen, and R. T. Lewellen

During the past 13 years numerous selections have been made from sugarbeet varieties and breeding lines for resistance to yellows. The most promising of the self-sterile selections have been used as pollen parents in hybrids. Self-fertile lines showing good resistance have been used in hybrids as components of the seed-bearing parents.

Plans and Procedures

Hybrids utilizing promising open-pollinated selections as pollen parents were included in USDA and sugar company cooperative tests. Randomized block designs with five to ten replications were used in all tests. Yellows infection ranged from light to severe.

Open-pollinated selections and hybrids involving these selections were planted in a test with ten replications at Salinas, December 21, 1966. All plants in the test were inoculated with a combination of beet and western yellows on April 26, 1967. The test was harvested October 9. Similar tests with the same selections and hybrids were planted at Salinas and sprayed with an aphicide in an effort to control the spread of yellows.

In addition to root yield and sucrose percentage, purity determinations were made from a portion of the tests. Union Sugar analyzed for thin juice purity in all of their cooperative tests. Sodium, potassium, and amino nitrogen determinations were made from the Salinas tests.

Results and Discussion

Foundation projects 12 and 24 are closely related. Many of the yellows resistant hybrids are included in the state-wide variety tests. Complete reports on these tests are reported on pp. 23-57 "Development and Evaluation of Inbred Lines and Hybrid Varieties Suitable for California". Summary tables are included in this report.

Performance of yellows resistant selections

The yellows resistant selection 613 was made available for increase in 1967. 613 is the seventh successive selection from US 75 and represents two selections beyond 413, the pollen parent in US H9A and US H9B. 613 was included in the variety tests in 1966 and 1967 along with US 75. A comparison of the root yields and sucrose percentages (table 1) shows that 613 yielded approximately 50% more than US 75 under conditions of medium to severe yellows. In two tests, under light yellows, 613 yielded 3% more than did US 75. The sucrose percentage tended to be higher for 613 than for US 75 when the beets were infected with yellows.

Table 1. Performance of 613, the seventh successive yellows resistant selection from US 75, compared with the performance of US 75 in 1966 and 1967 California variety tests.

Location	613		US 75	
	Root Yield	Sucrose	Root Yield	Sucrose
	<u>Tons</u>	<u>Percent</u>	<u>Tons</u>	<u>Percent</u>
<u>Severe yellows</u>				
Salinas - 1966	26.0	16.2	16.3	14.3
Davis - 1966	23.5	12.9	16.6	12.5
Salinas - 1967	30.0	13.1	17.8	12.9
Davis - 1967	17.3	12.5	12.5	11.7
Average	24.2	13.7	15.8	12.9
613 in % of US 75	153%	106%		
<u>Moderate yellows</u>				
Brawley - 1966	20.4	15.7	13.9	15.8
Salinas - 1967	37.1	13.2	25.1	13.5
Brawley - 1967	32.2	14.1	20.7	13.2
Brawley - 1967	31.3	14.0	22.6	14.0
Average	30.3	14.3	20.6	14.1
613 in % of US 75	147%	101%		
<u>Light yellows</u>				
Davis - 1966	28.8	13.7	27.5	14.0
Davis - 1967	22.4	12.9	22.1	13.1
Average	25.6	13.3	24.8	13.6
613 in % of US 75	103%	98%		

One of the outstanding lines in the 1967 tests was the yellows resistant selection Y603 from 534. Y603 was selected on the basis of both root size and sucrose percentage. In the inoculated test at Salinas, Y603 headed a group of 28 selections and hybrids in sugar yield and sucrose percentage. The line also showed the lowest impurity index. The results indicated that an improvement had been made over the parent 534 line which we received from Dr. Henk Rietberg of the Instituut voor Rationele Suikerproductie in the Netherlands. Y603 will be thoroughly tested in 1968.

Performance of hybrids utilizing yellows resistant selections from US 75 as the pollen parent.

Hybrids with three yellows resistant selections from US 75 were tested in 1967 (tables 2 and 3). 413 is the fifth successive selection from US 75 and has been increased as a commercial pollen parent. The 613 selection is described above and is currently being increased for use as a pollen parent. FS 4 is a selection from US 75 made by Dr. J. M. Fife on the basis of amino acid pattern and root size.

The performance of hybrids with 413 and 613 was similar. Hybrids with both pollinators showed a marked increase in sugar yield over US H7 when tested under conditions of moderate to severe yellows. The hybrid with FS 4 was tested in the Imperial Valley and failed to perform any better than did US H7 in two tests. The hybrid was not tested in the Salinas Valley.

Table 2. Gross sugar yields of yellows resistant hybrids in 1967 variety tests expressed in percent of the yield of US H7.

Location	413H8	F66-13H4	F66-13H11	613H4	FS4H4
<u>Severe yellows</u>					
Salinas (inoc.)	122	120	124	115	--
<u>Moderate yellows</u>					
Salinas (10 x 10)	--	111	113	111	--
Salinas (28 x 10)	110	--	--	--	--
Salinas (12 x 10)	--	107	105	113	--
Brawley (E.H.)	124	123	125	119	94
Brawley (L.H.)	--	134	138	144	103
Imp. Val. (USDA)	--	115	120	--	--
Imp. Val. (1st har.)	--	120	123	--	--
Imp. Val. (2nd har.)	--	125	131	--	--
Imp. Val. (3rd har.)	--	119	124	--	--
<u>Light yellows</u>					
King City	--	108	116	--	--
San Lucas	--	112	116	--	--
Soledad	--	115	122	--	--
El Centro	--	116	119	--	--
Imp. Valley	--	119	119	--	--
Tulare	--	112	108	--	--

Table 3. Sucrose percentage of yellows resistant hybrids in 1967 variety tests expressed in percent of US H7.

Location	413H8	F66-13H4	F66-13HL1	613H4	FS4H4
<u>Severe yellows</u>					
Salinas (inoc.)	105	102	100	100	--
<u>Moderate yellows</u>					
Salinas (10 x 10)	--	102	102	100	--
Salinas (28 x 10)	99	--	--	--	--
Salinas (12 x 10)	--	95	93	99	--
Brawley (E.H.)	99	101	101	93	94
Brawley (L.H.)	--	105	107	104	104
Imp. Val. (USDA)	--	105	101	--	--
Imp. Val. (1st har.)	--	102	99	--	--
Imp. Val. (2nd har.)	--	102	100	--	--
Imp. Val. (3rd har.)	--	104	102	--	--
<u>Light yellows</u>					
King City	--	98	96	--	--
San Lucas	--	99	98	--	--
Soledad	--	103	101	--	--
El Centro	--	100	102	--	--
Imp. Valley	--	104	102	--	--
Tulare	--	105	103	--	--
413H8 = (562HO x 546) x 413 F66-13H4 = (562HO x 569) x 413 F66-13HL1 = (563HO x 550) x 413 613H4 = (562HO x 569) x 613 FS4H4 = (562HO x 569) x FS4					

Performance of hybrids with two or more yellows resistant parents

Significant progress has been made in developing multigerm, yellows resistant, open-pollinated lines to serve as pollen parents in hybrids. Emphasis is now being placed on the development of yellows resistant inbreds and male steriles for use as components in seed-bearing parents. To date, greater progress has been made in selecting resistant multigerm than in selecting monogerm inbreds. The original SLC 101 monogerm is extremely susceptible to yellows and most of the newer monogerm inbreds we have tested are also susceptible.

The 705 monogerm inbred developed from a cross between a resistant multigerm line and a self-fertile monogerm showed good resistance in 1966 and 1967 tests. The 760 line was the most resistant of the multigerm inbreds. The hybrid (563HO x 760) x 705 showed about the same yield loss from yellows as did US H9A but was inferior in root yield in two Salinas tests (tables 4 and 5). The hybrids (563HO x 760) x 13 and (563HO x 754) x 13 were also tested in 1967. Neither of these hybrids was superior to US H9A or US H9B in resistance or performance even though two parents of each hybrid had been selected for yellows resistance.

The results demonstrate that inbreds with improved resistance can be developed. Additional work is required to incorporate this resistance with good combining ability and other desired characteristics.

Performance of triploid hybrids

In triploid hybrids, two genomes are furnished by the tetraploid parent and one genome by the diploid parent. If the tetraploid parent is yellows resistant the resulting triploid hybrid could very possibly have a higher level of resistance than the corresponding diploid hybrid. In two Salinas tests, the performance of the triploid hybrid (562HO x 569) x 30 Tetra was compared with that of the corresponding diploid hybrid. The pollen parent, 30, is a yellows resistant selection from US 75. One test was inoculated with yellows and the second was sprayed to delay natural infection. In neither of these tests (tables 4 and 5) was there a significant difference between the yield or sucrose percentage of the two hybrids.

A triploid hybrid with the parentage (563HO x 753) x 30 (Tetra) performed well in three Salinas tests but was not superior to diploid hybrids with resistant pollen parents. The 753 inbred has been selected for yellows resistance.

The 1967 results do not indicate any advantage for the triploid hybrids, but additional work is required. Triploid hybrids involving tetraploid pollinators with good yellows resistance will be included in several 1968 tests.

Yellows resistance and juice purity

The three impurity components; amino nitrogen, sodium, and potassium; were found to be higher from yellows inoculated beets of a given variety or selection than from noninoculated beets. These three components were also higher in the US 75 variety than in the yellows resistant selections from US 75. This was particularly true in tests that had been inoculated with yellows. The yellows resistant selection Y603 was low in these impurity components both at Salinas and at Davis.

Hybrids utilizing the yellows resistant selections as pollen parents tended to be lower in impurities than was the US H7 variety when grown under conditions of moderate to severe yellows.

Table 4

VARIETY TEST, SALINAS, CALIFORNIA, 1967

(10 replications of each variety) (One-row plots)										
Variety	Description	Acre Yield		Sucrose Percent	Bolting Percent	N PPM	Na PPM	K PPM	Imp. Index	Harvest Count Number
		Sugar Pounds	Beets Tons							
413H8	(562H0 x 546) x 13	10,490	38.04	13.8	11.4	607	382	2,088	918	110
630TH22	(563H0 x 753) x 30 (Tetra)	10,340	37.68	13.7	11.9	727	371	2,227	1,031	116
613H29	(563H0 x 754) x 13 sel.	10,290	37.41	13.8	10.6	663	275	2,212	956	112
610	YRS(321 x 234)	10,270	36.44	14.1	3.5	588	620	1,967	919	110
Y603	YRS 34	10,110	34.09	14.9	4.4	613	326	1,946	818	114
544H4	(562H0 x 569) x 44	10,080	36.80	13.7	13.1	873	371	2,222	1,137	116
534	Rietberg YRS	10,040	35.06	14.3	5.7	642	513	1,890	902	113
630	YRS 30	9,930	36.10	13.8	5.7	778	325	2,514	1,105	115
F64-30H4	(562H0 x 569) x 30	9,800	35.46	13.8	10.2	972	306	2,247	1,183	114
613B	7th YRS US 75	9,770	37.10	13.2	12.3	587	382	2,447	1,015	114
544	Increase (330 x 234)	9,740	35.84	13.6	17.5	658	545	2,129	1,017	111
630TH4	(562H0 x 569) x 30 (Tetra)	9,690	36.07	13.4	22.3	635	411	2,169	986	116
263TH4	(562H0 x 569) x 63 (Tetra)	9,570	35.68	13.5	7.5	825	474	2,479	1,201	115
664H4	(562H0 x 569) x 64	9,550	34.32	13.9	5.1	861	303	2,295	1,105	116
637	YRS 63	9,060	34.25	13.2	19.5	632	616	2,600	1,136	114
664HL4	(563H0 x 534) x 64	8,930	32.77	13.7	7.7	874	298	2,198	1,121	115
6705H24	(563H0 x 760) x 705	8,860	31.83	13.9	30.7	716	264	1,707	887	114
630T	Tetra 30	8,680	32.63	13.3	14.2	741	490	2,329	1,125	99
6403HL1	(563H0 x 550) x 403	8,300	29.92	13.9	24.0	668	442	2,017	956	114
Y601	Comp. of YRS	8,210	30.31	13.6	41.3	706	529	2,316	1,083	108

VARIETY TEST, SALINAS, CALIFORNIA, 1967 (continued from page 84)

(10 replications of each variety)
(One-row plots)

Planted: December 20, 1966
Harvested: October 3, 1967

Variety	Description	Acre Yield		Bolting Percent	N PPM	Na PPM	K PPM	Imp. Index	Harvest Count Number
		Sugar Pounds	Beets Tons						
6403H15	(562H0 x 648) x 403	8,170	28.64	14.3	649	386	1,912	885	103
Y602	YRS 64	8,000	29.80	13.4	657	491	2,429	1,069	113
6702H24	(563H0 x 760) x 702	7,630	27.46	13.9	814	232	1,954	997	105
F63-64	BRS 63	7,580	28.53	13.3	755	518	2,587	1,192	114
FS4	Fife YRS US 75	7,290	27.00	13.5	771	369	2,333	1,100	110
FS7	Fife YRS US 75	6,770	24.54	13.8	739	489	2,038	1,027	113
F57-68	US 75	6,730	25.05	13.5	745	506	2,307	1,113	112
590-9	Doney (SLO 54-1)	5,180	22.01	11.7	554	948	2,202	1,224	113
General MEAN of all varieties									
Significant Difference (19:1)		8,900	32.53	13.7	716	435	2,206	1,043	Beets per 100' row
Coefficient of Variation (%)		519	1.93	0.42	138	110	171	113	
Calculated F value		6.59	6.70	3.44	28.65	28.68	8.76	12.24	
		52.47**	42.26**	12.31**	93.84**	13.66**	13.38**	7.29**	

** Exceeds the 1% point of significance (F=1.97)

Table 5

VARIETY TEST, SALINAS, CALIFORNIA, 1967

(10 replications of each variety)
(One-row plots, inoculated with yellows)Planted: December 21, 1966
Harvested: October 9, 1967

Variety	Description	Acre Yield		Sucrose Percent	Bolting Percent	N PPM	Na PPM	K PPM	Imp. Index	Harvest Count
		Sugar Pounds	Beets Tons							
Y603	YRS 34	9,200	31.22	14.7	2.0	700	611	2,103	978	119
610	YRS (321 x 234)	8,750	32.06	13.7	3.0	648	1,033	2,066	1,116	116
544	Increase (330 x 234)	8,640	32.39	13.4	11.9	692	746	2,316	1,146	113
F66-13H11	(563H0 x 550) x 13	8,600	32.97	13.0	4.6	744	544	2,155	1,129	115
534	Rietberg YRS	8,460	30.46	13.9	5.7	755	793	2,269	1,148	112
413H8	(562H0 x 546) x 13	8,450	30.95	13.7	7.0	737	534	2,194	1,082	112
F66-13H4	(562H0 x 569) x 13	8,300	31.58	13.2	3.3	833	510	2,249	1,194	114
613H29	(563H0 x 754) x 13 sel.	8,130	30.48	13.3	7.2	794	528	2,488	1,203	109
544H4	(562H0 x 569) x 44	8,110	30.64	13.3	7.2	1,041	667	2,368	1,405	114
630	YRS 30	8,090	29.77	13.6	3.6	1,337	586	2,812	1,654	114
613H4	(562H0 x 569) x 13 sel.	8,000	30.94	13.0	6.7	957	515	2,423	1,349	108
613H24	(563H0 x 760) x 13 sel.	8,000	30.56	13.1	10.5	889	436	2,377	1,249	108
613A	YRS, sucrose sel. US 75	7,900	28.62	13.8	8.9	759	494	2,493	1,123	110
613B	7th YRS US 75	7,840	30.00	13.1	8.4	684	619	2,726	1,207	115
630TH22	(563H0 x 753) x 30 (Tetra)	7,800	29.01	13.4	8.6	949	667	2,476	1,344	111
F64-30H4	(562H0 x 569) x 30	7,480	28.59	13.1	5.9	1,291	536	2,308	1,571	120
630TH4	(562H0 x 569) x 30 (Tetra)	7,180	27.95	12.9	18.2	800	656	2,231	1,234	114
637	YRS 63	7,010	30.00	13.1	8.4	684	619	2,726	1,207	107
664H4	(562H0 x 569) x 64	6,930	26.69	13.0	6.4	871	679	2,351	1,310	115
630T	Tetra 30	6,860	26.79	12.8	7.1	896	748	2,320	1,358	97

(Continued on page 87.)

VARIETY TEST, SALINAS, CALIFORNIA, 1967 (continued from page 86)

(10 replications of each variety)
(One-row plots, inoculated with yellows)

Planted: December 21, 1966
Harvested: October 9, 1967

Variety	Description	Acre Yield			Bolting Percent	N PPM	Na PPM	K PPM	Imp. Index	Harvest	
		Sugar Pounds	Beets Tons	Sucrose Percent						Count Number	Number
6705H24	(563H0 x 760) x 705	6,780	25.55	13.3	23.6	1,007	460	1,982	1,256		108
Y601	Comp. of YRS	6,750	25.90	13.1	37.4	760	849	2,421	1,275		112
Y602	YRS 64	6,480	24.88	13.0	7.4	705	838	2,713	1,286		112
F63-64	BRS 63	5,840	22.96	12.7	8.1	902	772	2,633	1,436		110
FS7	Fife YRS US 75	5,440	20.47	13.3	36.9	729	770	2,056	1,139		115
FS4	Fife YRS US 75	5,360	21.35	12.6	27.8	996	775	2,513	1,513		107
6702H24	(563H0 x 760) x 702	5,280	20.26	13.0	14.5	970	505	2,048	1,276		102
F57-68	US 75	4,580	17.80	12.9	9.5	1,136	765	2,480	1,582		111
General MEAN of all varieties											
		7,370	27.83	13.2	11.3	872	667	2,370	1,289	Beets	
Significant Difference (19:1)		529	2.22	0.40	4.0	255	118	185	212	per	
Coefficient of Variation (%)		8.11	9.01	3.39	39.92	33.00	19.99	8.80	18.60	100'	
Calculated F value		40.53**	26.44**	10.79**	43.41**	3.73**	14.24**	11.97**	4.94**	row	

** Exceeds the 1% point of significance (F=1.97)

PERFORMANCE OF TWO SUGARBEET SELECTIONS MADE BY DIFFERENT
SELECTION SCHEMES FOR YELLOWS RESISTANCE IN THE SAME PARENT
VARIETY

by

J. M. Fife

McFarlane and Bennett (1) have made significant progress in breeding for resistance to beet yellows by mass selection, on the basis of top symptoms, root size and percent sucrose, from large populations of inoculated plants grown in the field. In extensive field tests, their selection, 413, developed by 5 cycles of selection for yellows resistance, has shown considerable tolerance to yellows.

I have used another selection scheme to identify plants having tolerance to yellows. Plants were selected on the basis of the amino acid ratio (concentration: $\frac{\text{aspartic acid} + \text{glutamic acid}}{\text{glutamine}}$), in newly matured leaves and root weight, from large populations of inoculated plants of US 75, grown in the greenhouse under controlled nutritional conditions.

Tests are reported which compare the performance in the field and the amino acid ratios (determined on yellows-infected plants grown in the greenhouse) of McFarlane's and Bennett's yellows-tolerant selection and a selection made on the basis of the amino acid ratio and root weight. Both selections were from variety, US 75.

Methods and Results

The selection scheme, used by McFarlane and Bennett, and the performance of selection 413, showing considerable tolerance to beet yellows, have been reported (1).

Briefly, the scheme I used in identifying plants showing tolerance to beet yellows was as follows: Approximately 1200 plants of US 75, were grown in the greenhouse in sand-culture. They were inoculated with a virulent strain of the beet yellows virus (strain 5) in the 2-leaf stage. The concentrations of aspartic acid, glutamic acid and glutamine were determined in the expressed juice from 2 newly matured leaves taken from each plant after the chronic symptoms of the disease appeared. The amino acid ratio was calculated for each plant. After 100 days of growth the plants were weighed. Only 28 plants were saved for seed increase. Each plant had an amino acid ratio greater than the mean for the population and a root weight greater than the population mean by at least 2 standard deviations. A second cycle of selection was made in the same manner from a population of approximately 1000 plants. Only 10 plants were saved for seed increase. In this cycle, each plant had both an amino acid ratio and a root weight greater

than the population means by at least 2 standard deviations. Seed was harvested on an individual plant basis in each cycle and further seed increases made for field and greenhouse testing.

Some of the sibs of both selection cycles produced greater top growth, were greener and had fewer dead leaves at harvest than the parent variety.

One of the most yellows-tolerant sibs (RS-3) of the second selection cycle was tested four successive years in the field in replicated tests. The sugar per acre yield and the percentage sucrose was significantly greater than the parent at the 1% level in all tests (Figures 1, and 2). The mean percentage sucrose was 1.6 percentage points higher than the parent.

In the 1963 and 1964 tests, the plants were inoculated with strain 5, of the beet yellows virus. In these tests the yield of beets was greater than the parent but not significantly so. The 1963 test was inoculated after 47% of the growing period had past. This would account for the relatively small difference in yield between the selection and the parent. In the 1965 and 1966 tests, the plants were inoculated with the "Brawley" strain, which is more virulent than strain 5. In these two tests, the yield of beets of the selection was significantly greater than the parent. This suggests that this selection, and possibly other sibs of the second selection cycle, may show greater tolerance than the parent variety to the most virulent strains of the beet yellows virus.

Yellows-tolerant selection, 413, (developed by McFarlane and Bennett) was included in an 8 by 8 latin-design field test (1966) to compare its performance with selections made on the basis of the amino acid ratio and root weight. Plants, of the selections tested in the field, were also grown in the greenhouse to determine their amino acid ratios. Plants, in both the field and greenhouse tests were inoculated with the more virulent strain ("Brawley") of the beet yellows virus. The performance of selection 413 and one of the most outstanding sibs (RS-3) of the second selection cycle (made on the basis of the amino acid ratio and root weight) are compared with their common parent, US 75, (Table 1).

These two selections show a similar degree of tolerance to a virulent strain of the beet yellows virus even though each was developed by a different selection scheme. Their sucrose percentages and amino acid ratios were practically the same but significantly greater than their parent. The yield of beets and sugar of selection 413 was, however, significantly greater than selection RS-3.

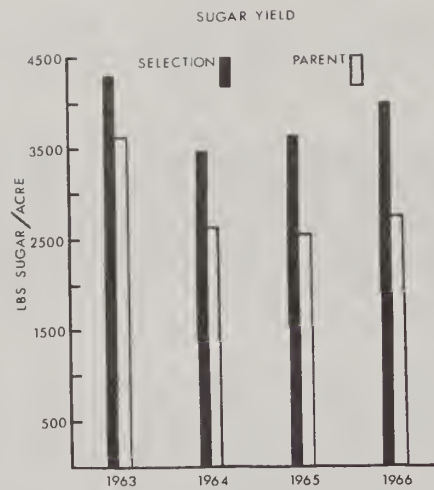


Fig. 1. Yield of sugar of parent and a selection made for resistance to beet yellows on the basis of the amino acid ratio and root weight.

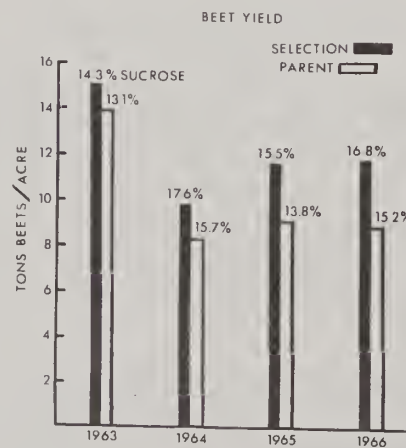


Fig. 2. Percent sucrose and yield of beets of parent and a selection made for resistance to yellows on the basis of the amino acid ratio and root weight.

Table 1

Performance of two beet yellows-tolerant selections, each made by applying a different selection scheme to the same parent.

Selection	Sucrose	Acre Yield		Amino Acid Ratio ^{1/}
		Beets	Sugar	
	%	Tons	Pounds	
US 75 (Parent)	15.2	8.9	2,726	.21
413 (5th sel. cycle)	16.5	14.4	4,740	.39
RS-3 (2nd sel. cycle)	16.8	11.8	3,978	.45

^{1/} Amino Acid Ratio: $\frac{\text{Aspartic} + \text{Glutamic}}{\text{Glutamine}}$

Discussion

It has been shown that the correlation between the amino acid ratio of yellows-tolerant selections and the percentage sucrose is positive and highly significant, while the correlation between the amino acid ratio and root yield is positive and significant only at the 10% level in sibs of the second selection cycle (2).

The fact that selection 413 (developed on the basis of root weight and top symptoms) also had a significantly higher amino acid ratio than the parent variety is further evidence that this ratio is correlated with tolerance to yellows. It is also possible that the greater top growth, with greener foliage, and with fewer dead leaves, as shown by both selections at harvest, may also be correlated with a high amino acid ratio.

Summary

Two sugarbeet selections (each made by a different selection scheme for yellows resistance) were tested in the field and grown in the greenhouse for the determination of the amino acid ratio. All plants in both tests were inoculated with a virulent strain (Brawley) of the beet yellows virus. The selections showed similar tolerance to yellows. They were significantly superior to their parent in percent sucrose, yield of beets and sugar per acre. Both selections had an amino acid ratio significantly greater than that of their parent.

References

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INTERSPECIFIC HYBRIDIZATION

VULGARES-PATELLARES HYBRIDS

Helen Savitsky

Three generations of hybrids between sugarbeets and Patellares species were tested for resistance to nematode (Heterodera schachtii) in 1967. Each plant selected was tested 3 times. In the first test seedlings were planted in soil heavily infested by nematode cysts. Plants having on the roots 0 to 5 females (Group 1), and 5 to 10 females (Group 2) were selected and exposed to the second test. In the second and third test, plants were planted in nematode infested soil and 15 viable cysts were added to each plant. The technique of nematode infestation - the use of soil heavily infested by cysts, and a proper control of temperature during the test permitted a severe infestation of plants by nematode.

A total of 3,080 plants was tested for resistance. Among these were 2,537 b_1 hybrids, 462 b_2 hybrids, and 81 b_3 hybrids. All b_3 hybrids were derived from b_2 plants which carried the 19th chromosome responsible for resistance. In the progeny of these hybrids, 2 resistant plants were selected. One plant had no females on the roots in 4 checks, the other had 2 cysts in one of 4 tests. Being selected for resistance after 3 tests, as usual, these 2 plants were exposed to the fourth test. The aim was to grow the hybrids under the heaviest infestation possible. Therefore, besides the nematode infested soil in which the plants were growing, 15 viable cysts were added to them, and after 3 weeks of growth Dr. Doney added larvae to each plant. No females were found on the roots of either plant in the fourth test.

The b_3 plants selected are of sugarbeet type, they develop fleshy roots, although the leaves are narrower than in the ordinary sugarbeets. Both plants have 18 chromosomes.

No one plant was selected for resistance in the b_2 generation.

Of 2,537 b_1 hybrids 8 plants were selected in the first group, and 4 plants in the second group. The number of b_1 plants selected for resistance was much lower than in the experiments conducted a few years ago, obviously due to the result of effective technique of infestation.

At the same time b_1 generation manifested other characters which indicated that the chromosomes, or segments of chromosomes of Patellares species were transferred from F_1 to b_1 hybrids. In the population of b_1 hybrids 54 plants developed tumors on the roots, or on the leaves; 7 plants were annual - they had seed stalks and flowered very early; 47 seedlings

were inviable because they did not develop root system, like the inviable F_1 hybrids; 3 plants did not develop fleshy roots, they had elongated cylindric roots, like Patellares species; 20 plants were dwarf and died in 2-3 weeks. Comparing the rate of transmission of other characters, the transmission of nematode resistance was not high. Inviability of seedlings, and tumor formation were the easiest transmitted characters. These data indicate that it is desirable to apply methods on F_1 hybrids which will facilitate the breakage and crossing over of chromosomes.

A new population of triploid and tetraploid F_1 hybrids has been produced. The plants are free from virus yellow and other virus diseases. They are growing in the greenhouse, and after exposure to thermal induction will be propagated by grafts to obtain a population of sufficient size for 1968 experiments.

EFFECT OF CURLY TOP ON HYBRIDS BETWEEN BETA VULGARIS AND

B. COROLLIFLORA

Helen Savitsky and C. W. Bennett

Plants of Beta corolliflora Zoss. have been proven by tests under greenhouse conditions to be highly resistant or immune to curly top. Hybrids were made, therefore, between B. corolliflora and B. vulgaris to determine whether resistance present in B. corolliflora could be incorporated in plants derived from hybrids between this and sugarbeet. The tetraploid F₁ hybrid between 4n sugarbeet and B. corolliflora, first obtained by Dr. V. F. Savitsky, was pollinated by diploid sugarbeets. All b₁ hybrids obtained were triploids or aneuploids approaching triploids. Four hundred plants of the b₁ hybrid were inoculated with virulent strains of the curly top virus in the seedling stage and 29 plants were selected from this lot as resistant. All b₁ hybrids were male-sterile. They were pollinated by 2n sugarbeets in 1965 and 1966 to obtain b₂ seed.

Of the b₂ seeds obtained, 257 plants were produced and these were used for resistance tests in 1967. Tests were made by inoculating all plants with highly virulent strains of curly top virus in the greenhouse. The first inoculations were made when the plants were in the 4- to 6-leaf stage by caging about 10 viruliferous beet leafhoppers on each plant. After 2 months or more all plants which showed no symptoms of curly top were reinoculated by placing 25, or more, viruliferous beet leafhoppers in sleeve cages and allowing the leafhoppers to feed on two or more leaves of each plant for about 2 weeks.

Following the second inoculation, and after a suitable period for production of symptoms, all plants were divided into the following three groups: (1) plants highly resistant, which showed no symptoms of disease, (2) plants susceptible, which showed a range of severity of curly top symptoms, and (3) plants very susceptible, which showed severe symptoms. The plants in the highly resistant group, which showed no symptoms, were tested for presence of virus by allowing nonviruliferous beet leafhoppers to feed on them for three days, after which the leafhoppers from each plant were caged on 12 seedling sugarbeet plants of a highly susceptible selection. Curly top virus was recovered from some of the symptomless plants, but not from others, indicating that some of the plants might be immune or at least very highly resistant to curly top.

The tests for immunity are being continued. At the present time 19 plants apparently immune to curly top have been selected. The tested population of the b₂ hybrids between B. vulgaris and B. corolliflora, has shown the following distribution with respect to reaction to curly top virus:

19 plants "apparently immune" which showed no symptoms and no virus was recovered; 99 plants "highly resistant" showed no symptoms but virus was recovered; 121 plants "susceptible" showed a range of severity symptoms from mild to severe; and 18 plants "very susceptible" showed severe symptoms and eventually died (Table 1).

Table 1 ... Distribution of b_2 Beta vulgaris x Beta corolliflora hybrids according to the grade of curly top resistance.

Degree of resistance	Number of plants
Apparently immune	19
Highly resistant	99
Susceptible	121
Very susceptible	18

The number of chromosomes was determined in the plants apparently immune and in some of the highly resistant plants. Of 19 immune plants - 2 had 20 chromosomes, 2 had 23 chromosomes, and the remaining 15 plants had 22 chromosomes. In the group of highly resistant hybrids many plants had 22 chromosomes; some plants, however, had 20, 21 or 25 chromosomes.

Comparing to the previous b_1 generation, which was triploid (27 chromosomes), or triploid-aneuploid, the number of chromosomes of corolliflora species is reduced in the b_2 generation. At the same time, the b_2 hybrids still carry 2 to 5 chromosomes in excess of diploid number of chromosomes in Beta vulgaris (18 chromosomes). Most of these additional chromosomes obviously are the chromosomes of the wild species, B. corolliflora. The majority of plants in both groups "immune" and "highly resistant" have 22 chromosomes, which probably includes 4 chromosomes of B. corolliflora. In some slides the chromosomes of B. corolliflora could be distinguished from B. vulgaris chromosomes by their longer length and a specific for the section Carollinea constriction. In the karyotype of some plants, having 22 chromosomes, 3 or 4 B. corolliflora chromosomes could be recognized.

Difference in the grade of curly top resistance demonstrated by b_2 hybrids is due to the genes responsible for curly top resistance or susceptibility which were transferred to them by the chromosomes of B. corolliflora.

The plants immune and highly resistant obtained the chromosomes carrying the genes providing for curly top resistance; the susceptible plants lost these chromosomes and obtained the chromosome of wild species which are not responsible for resistance. The number of chromosomes in the "susceptible" group is not yet determined, although their morphological characteristics show beyond doubt that plants carry some chromosome of wild species.

Hybrids which carry the same number of chromosomes of B. corolliflora may differ in the grade of resistance to curly top in dependence of the genes located in the chromosomes transferred to them. It is very important that the chromosomes of B. corolliflora responsible for a high grade of curly top resistance are transferred and fixed in the b_2 generation. A further study and selection of hybrids will attempt the elimination of chromosomes of wild species which are not responsible for resistance and the incorporation of segments of B. corolliflora chromosomes which carry the genes for curly top resistance in B. vulgaris chromosomes.

STUDIES IN POLYPLOIDY

Helen Savitsky

FRUIT VARIABILITY IN DIPLOID, TRIPLOID, AND TETRAPLOID MATINGS.

A study of seed viability at different ploidy levels has a theoretical and practical value. The main purpose of such a study consists in investigation of some genetic processes that may influence the viability of fruits at different ploidy levels and in different biological groups of plants (multigerm, monogerm, male-sterile). Experiments were conducted on isolation plots and in the greenhouse.

In the 1966 experiments the effectiveness of fertilization and ovule development was studied in diploid, triploid, and tetraploid matings. Diploid male-sterile lines were pollinated by diploid and tetraploid multigerm and monogerm populations. The number of unfertilized, and fertilized normal and aborted ovules was determined in 100 fruits of 5 plants in each male-sterile line, and of 5 plants in the populations pollinators. The results of this study were given in the 1966 report.

Seed harvested on all plants examined for ovule development were tested for germination in 1967. The data concerning the viability of diploid, triploid, and tetraploid fruits are reported here.

Ovule development and fruit germination were investigated in the reciprocal $2n \times 4n$ crosses conducted in greenhouse.

1. FRUIT GERMINATION IN DIPLOID AND POLYPLOID MATINGS

MATERIALS AND METHODS

Eight diploid male-sterile lines, SLC 502, F_1 64-569-H3, F-61-562-HO, SLC 91, U.I. 129, A-61225, A-61226, and A-63113 were pollinated by diploid and tetraploid monogerm and multigerm populations in 8 different isolations. The pollinators were (1) 2 diploid monogerm populations 4-568 and, SLC 91, (2) 2 diploid multigerm populations, 112 and US 401, (3) 2 tetraploid monogerm populations SLC 15 and Klein E, and (4) 2 tetraploid multigerm populations, 4-601 and 4-900.

Seed were harvested individually from 5 plants in each male-sterile line in all matings, and from 5 plants in each population pollinator. A sample of seed for germination was taken at random from each plant studied. One hundred fruits from each plant were tested in 2 replications for germination. A total of 36,000 fruits from 360 plants were tested.

Fruits were washed in water for 3 hours, then put between 2 layers of wet blotting paper and placed in the oven for germination. Temperatures of 68° F. for 16 hours and of 86° F. for 8 hours were maintained. Sprouts obtained were calculated after 3, 7, and 10 days.

EXPERIMENTAL RESULTS

Fruit germination in diploid and tetraploid populations. Fruit germination in diploid and tetraploid open pollinated populations was comparatively high (Table 1). The average percent of germination for the diploid monogerm population was 82.70, and for the diploid multigerm population it was 84.52. Variation in percent of germination between different diploid populations was not wide: percent of germination fluctuated from 80.20 to 85.27. In the multigerm diploid populations an average of 1.95 sprouts was obtained per fruit, whereas the monogerm populations gave 0.83 sprouts per fruit.

Germination of tetraploid fruits was lower than germination of diploid fruits, but not to the extent that would prevent their agricultural use. The significance of the difference between viability of diploid and tetraploid fruits is not high. Variance ratio (F) for germination of 2n and 4n fruits equaled 4.55, against F tabulated 4.18 at 5% level (Table 2). The average percent of germination was 74.4 for tetraploid monogerm populations and 72.2 for tetraploid multigerm populations (Table 1).

The individual tetraploid populations differed much more in viability of fruits than the diploid populations. Percent of germination varied in tetraploid populations from 67.60 to 81.20. The average number of sprouts per fruit was 0.74 in the tetraploid monogerm populations and 1.53 in the tetraploid multigerm populations (Table 1). The tetraploid monogerm and multigerm populations produced fewer sprouts per fruit than the corresponding diploid populations. The least number of sprouts were obtained from fruits of multigerm tetraploid populations.

Fruit germination in male-sterile lines. Eight diploid male-sterile lines, pollinated by diploid and tetraploid populations, produced diploid and triploid fruits, respectively.

Fruit viability in male-sterile lines was lower in all matings than viability of fruits in the open pollinated populations-pollinators grown on the same isolations. In the diploid monogerm populations the average percent of fruit germination was 82.70 against 70.88 in the male-sterile lines pollinated by these populations. The multigerm diploid pollinator had 84.52% germinated fruits, against 75.45% in male-sterile lines. In the tetraploid monogerm pollinators, 74.40% of fruits germinated as compared to 64.28% in male-sterile lines pollinated by them. In the tetraploid multigerm pollinators 72.04% of fruits germinated; in the male-sterile lines only 55.38% of fruits germinated (Tables 1 and 3).

Table 1... Fruit germination in diploid and tetraploid monogerm and multigerm populations-pollinators.

Populations	500 fruits per 5 plants in each population				
	Fruits set for germina- tion	Locules per 500 fruits	S p r o u t	o b t a i n e d per number of locules	Average sprout per fruit
	Number	Number	Number	Percent	Number
<u>2n populations</u>					
4-558-m ₂	500	500	426	85.20	0.85
SLC 91-m ₂	500	500	401	80.20	0.80
Total	1,000	1,000	827		0.83
Percent				82.70	
112-M ₂	500	1,152	965	83.77	1.93
U.S.401-M ₂	500	1,154	984	85.27	1.97
Total	1,000	2,306	1,949		1.95
Percent				84.52	
Grand total	2,000	3,306	2,776		
Percent	100	100		83.97	
<u>4n populations</u>					
SLC 15-m ₄	500	500	338	67.60	0.68
Klein L-m ₄	500	500	406	81.20	0.81
Total	1,000	1,000	744		0.74
Percent				74.40	
4-601-M ₄	500	999	764	76.48	1.53
4-900-M ₄	500	1,122	764	68.09	1.53
Total	1,000	2,121	1,528		1.53
Percent				72.04	
Grand total	2,000	3,121	2,272		
Percent	100	100		72.80	

Table 2 ... Analysis of variance for fruit germination in
diploid and tetraploid populations-pollinators.

Source of variance	Sum of squares	d.f.	Mean squares	Variance ratio	F tabulated	
				F	0.5%	0.1%
Total sum of squares	254,292.31	39	211.69	< 1		
Crosses	1,239,050.37	7	253.37	1.13	2.35	3.33
2n vs. 4n	4,941,060.93	1	1,016.57	4.55	4.18	7.60
Multi vs. mono	4,920,741.53	1	0.60	< 1		
(2n vs. 4n) x (Multi vs. Mono)	2,470,854.17	1	31.77	< 1		
Error	-	29	223.53			

Table 3 ... Fruit germination in 8 diploid male-sterile monogerm lines in 8 matings with diploid and tetraploid monogerm and multigerm pollinators.

4,000 fruits per 8 male-sterile lines in a mating					
Matings	Sprouts obtained		Matings	Sprouts obtained	
	Number	Percent		Number	Percent
<u>2n mono-fruits</u>					
8 M.S. lines-m ₂ x 4-568-m ₂	2,951	73.78	8 M.S. lines-m ₂ x 112-M ₂	2,966	74.15
8 M.S. lines-m ₂ x SLC 91-m ₂	2,719	67.98	8 M.S. lines-m ₂ x U.S.401-M ₂	3,070	76.75
Total (16,000 fruits) Percent	5,670	70.88		6,036	75.45
<u>3n mono-fruits</u>					
8 M.S. lines-m ₂ x SLC 15-m ₄	2,371	59.38	8 M.S. lines-m ₂ x 4-601-M ₄	2,287	57.18
8 M.S. lines-m ₂ x Klein E-m ₄	2,771	69.28	8 M.S. lines-m ₂ x 4-900-M ₄	2,143	53.58
Total (16,000 fruits) Percent	5,142	64.28		4,430	55.38

Germination of diploid fruits obtained on male-sterile lines pollinated by 2 monogerm and 2 multigerm populations was sufficiently high. The average percent of sprouts obtained in different matings ranged from 67.98 to 76.75 (Table 3). The average germination of diploid fruits obtained from pollination by the multigerm populations was a little higher (75.45%) than of fruits from pollination by the monogerm populations (70.88%).

The multigerm diploid pollinators may have some advantage over the monogerm pollinators because of more pollen produced and better chances for selective fertilization. But such an advantage would not count for much and would largely depend upon the quality of pollen produced in the monogerm populations. In this experiment the decline in germination was observed only in male-sterile lines pollinated by the inbred SLC 91. Another monogerm pollinator, self-sterile population 4-568, produced fruits percent of germination of which was close to that of fruits obtained from pollination by the multigerm populations.

Triploid fruits were lower in germination than diploid fruits. Fruit viability was especially low when tetraploid multigerm populations were used as pollinators. The average percent of germination of triploid fruits obtained after pollination by the tetraploid monogerm populations was 64.28, and of the fruits produced by pollination by the tetraploid multigerm population it was only 55.38 (Table 3).

Analysis of variance for fruit germination in male-sterile lines indicated that difference between crosses was significant (F equals 29.63 against F tabulated 1.38 at 5% level (Table 4). The greatest significant difference was observed between germination of diploid and triploid fruits: F equals 48.44 and F tabulated is 3.89 and 6.76 at 5% and 1% levels, respectively. Difference in the viability of diploid and triploid fruits was influenced by both male and female parents but mainly by the pollinators. Variance ratio F for males was 10.36, whereas for females, it was only 2.66 against F tabulated 2.14 and 2.90 at 5% and 1% levels. The interaction ($3n$ vs. $2n$) \times (multi vs. mono) is also significant (F equals 12.36 and F tabulated is 3.89 and 6.76 at 5% and 1% levels).

But when triploid fruits, obtained from pollination by tetraploid monogerm populations, were compared with the diploid fruits, the difference in viability between diploid and triploid fruits was also significant but at much lower level. F for $3n$ vs. $2n$ fruits equaled 4.38, against F tabulated 3.92, and 6.84 at 5% and 1% levels (Table 5). Thus, triploid fruits derived from pollination by the tetraploid monogerm populations had almost the same grade of viability as the diploid fruits.

Individual male-sterile lines differed significantly in fruit viability regardless whatever pollinator was used for seed production. The lines A-61225, SLC 502, and A-61226 showed the highest fruit viability: they gave 3,008, 2,722, and 2,714 sprouts (sum from all matings). The lines

Table 4 ... Analysis of variance for fruit germination
in 8 male-sterile lines in all matings.

Source of variation	Sum of squares	d.f.	Mean squares	Variance ratio	F tabulated	
				F	5%	1%
Total	1,544,908	319	-	-		
Crosses	7,348,478	63	8,705.01	29.63	1.38	1.57
Male-sterile lines (females)	56,788,764	7	780.73	2.66	2.14	2.90
Matings (males)	57,446,318	7	3,043.42	10.36	2.14	2.90
Lines x matings	-	49	585.15	1.99	1.42	1.62
2n vs. 3n	228,653,620	1	14,231.12	48.44	3.89	6.76
Multig.vs. monog.	226,436,500	1	374.12	1.27	3.89	6.76
(2n vs. 3n) x (Multig.vs. monog.)	114,647,260	1	3,631.50	12.36	3.89	6.76
(2n vs. 3n) x lines	28,724,786	7	327.01	1.11	2.05	2.73
(Multig.vs. monog.) x Lines	28,473,244	7	509.85	1.74	2.05	2.73
Error	-	256	293.80	-		

Table 5 ... Analysis of variance for diploid and triploid fruits in 8 male-sterile lines pollinated by diploid and tetraploid monogerm populations.

Source of variation	Sum of squares	d.f.	Mean squares	Variance ratio	F tabulated	
				F	5%	1%
Total sum of squares	806,946	159	-	-	-	-
Crosses	3,780,344	31	820.9	-	-	-
2n vs. 3n	58,589,064	1	1,742.40	4.38	3.92	6.84
Error	-	128	397.48			

SLC 91 and U.I. 129 were the lowest in fruit viability: 2,547 and 2,441 sprout were obtained from them respectively. Viability of fruits fluctuated greatly in different plants within all male-sterile lines. In a line with plants which had high percent of fruit germination, the other side by side growing plants pollinated by the same population were low in fruit germination. For instance, in the male-sterile line 129 pollinated by the diploid monogerm population, the individual plants had 82, 72 and 31 percent of germinated fruits. In the male-sterile line F-61-562 H0 pollinated by the diploid multigerm population in line with plants having 98% and 78% germinated fruits - were plants with 52 and 27 percent of germination. In the line, A-61225, pollinated by a tetraploid monogerm population - fruits of the individual plants had 97, 92 and 14 percent germination. Male-sterile line 129 pollinated by a tetraploid multigerm population contained plants with 73%, 65% and 19% of germinated fruits.

A high degree of fluctuation among the plants within male-sterile lines is responsible also for a part of variability in fruit germination manifested by the same male-sterile line in different matings (Tables 6, 7, 8, 9).

In spite of a certain variability in fruit germination, some male-sterile lines, pollinated by tetraploid populations, especially by monogerm tetraploids, produced triploid fruits with a sufficient percent of germination for commercial planting (over 70%). Such were the male-sterile lines SLC 502, A-61225, A-61226, and F-61-562-H0 with an average percent germination of triploid fruits from 70 to 85 percent (Table 8).

A corresponding study of ovule development and fruit germination in diploid and tetraploid matings was conducted in 1967. Other male-sterile lines and other populations pollinators were used to verify the results obtained last year. Examination of ovule development and ovule abortion confirmed the data of 1966. Statistically analyzed data of this experiment and the data of fruit germination will be given in the next year report.

2. RECIPROCAL DIPLOID-TETRAPLOID MATINGS IN MULTIGERM AND MONOGERM BEETS.

The reciprocal diploid-tetraploid crosses, as well as hybridization of diploid plants with tetraploids and tetraploids with diploids, should show whether female parent influences the viability of triploid fruits. In the experiments conducted, diploid and tetraploid multigerm beets and diploid and tetraploid monogerm beets were intercrossed. The plants were bagged in the greenhouse and pollinated by exchanging of bags. In the multigerm matings 50 fruits collected from each diploid and tetraploid plant were examined for the number of unfertilized and fertilized normal and aborted ovules (Tables 10 and 11; matings from 1 to 22 are reciprocals). Percent of unfertilized ovules in both-way crosses was the same regardless of whether the female parent was a diploid (30.09% unfertilized ovules), or a tetraploid plant (30.12% unfertilized ovules). Percent of unfertilized ovules is not characteristic for $2n$ and $4n$ plants in the given case because a certain percent of unfertilized ovules is due to insufficient pollination.

(cont. pg. 113).

Table 6... Fruit germination in 8 diploid male-sterile monogerm lines
pollinated by diploid monogerm populations.

M.S. lines - m ₂ x 4-568m ₂				M.S. lines-m ₂ x S.L.C. 91 m ₂				
500 fruits per 5 plants in a line				500 fruits per 5 plants in a line				
Male-sterile lines	Fruits set for germination		Sprouts obtained		Male-sterile lines	Fruits set for germination		Sprouts obtained
	Number	Percent	Number	Percent		Number	Percent	
S.L.C. 502	500	443	88.60		S.L.S. 502	500	270	54.00
F ₁ -64-569-H3	500	345	69.00		F ₁ -64-569-H3	500	235	47.00
F-61-562 H0	500	373	74.60		F-61-562 H0	500	260	52.00
S.L.C. 91	500	394	78.80		S.L.C. 91	500	421	84.20
U.I. 129	500	329	65.80		U.I. 129	500	324	64.80
H-61225	500	371	74.20		A-61225	500	419	83.80
A-61226	500	359	71.80		A-61226	500	354	70.80
A-63113	500	337	67.40		A-63113	500	436	87.20
Total	4,000	2,951	73.78			4,000	2,719	67.98

Table 7 ... Fruit germination in 8 diploid male-sterile monogerm lines
pollinated by diploid multigerm populations.

M.S. lines - $m_2 \times U.S. 401 M_2$				M.S. lines - $m_2 \times 112-M_2$			
500 fruits per 5 plants in a line				500 fruits per 5 plants in a line			
Male-sterile lines	Fruits set for germination		Sprouts obtained	Male-sterile lines	Fruits set for germination		Sprouts obtained
	Number	Percent			Number	Percent	
S.L.C. 502	500	367	73.40	S.L.C. 502	500	456	91.20
F ₁ 64-569 H3	500	418	83.60	F ₁ 64-569 H3	500	381	76.20
F-61-562 H0	500	373	74.60	F-61-562 H0	500	327	65.40
S.L.C. 91	500	344	68.80	S.L.C. 91	500	294	58.80
U.I. 129	500	382	76.40	U.I. 129	500	381	76.20
A-61225	500	427	85.40	A-61225	500	420	84.00
A-61226	500	351	70.20	A-61226	500	355	71.00
A-63113	500	408	81.60	A-63113	500	352	70.40
Total	4,000	3,070	76.75		4,000	2,966	74.15

Table 8 ... Fruit germination in 8 diploid male-sterile monogerm lines
pollinated by tetraploid monogerm populations.

M.S. lines m ₂ x S.L.C. 15-m ₄		M.S. lines x Klein E - m ₄	
500 fruits per 5 plants in a line		500 fruits per 5 plants in a line	
Male-sterile lines	Fruits		Sprouts obtained
	set for germination	set for germination	
	Number	Number	Percent
S.L.C. 502	500	366	73.20
F ₁ -64-569 H3	500	296	59.20
F-61-562-HO	500	301	60.20
S.L.C. 91	500	159	31.80
U.I. 129	500	289	57.80
H-61225	500	326	65.20
A-61226	500	351	70.20
A-63113	500	283	56.60
Total		4,000	2,371
Percent		4,000	59.28
		2,771	69.28

Table 9... Fruit germination in 8 diploid male-sterile monogerm lines
pollinated by tetraploid multigerm pollinators.

M.S. lines - $m_2 \times 4-601-M_4$				M.S. lines - $m_2 \times 4-900-M_4$			
500 fruits per 5 plants in a line				500 fruits per 5 plants in a line			
Male-sterile lines	Fruits set for germination		Sprouts obtained	Male-sterile lines	Fruits set for germination		Sprouts obtained
	Number	Percent			Number	Percent	
S.L.C. 502	500	253	50.60	S.L.C. 502	500	187	37.40
F ₁ -64-569 H3	500	299	59.80	F ₁ -64-569 H3	500	285	57.00
F-61-562 H0	500	350	70.00	F-61-562 H0	500	230	46.00
S.L.C. 91	500	366	73.20	S.L.C. 91	500	326	65.20
U.I. 129	500	219	43.80	U.I. 129	500	213	42.60
A-61225	500	235	47.00	A-61225	500	335	67.00
A-61226	500	260	52.00	A-61226	500	283	56.60
A-63113	500	255	51.00	A-63113	500	284	56.80
Total	4,000	2,287	57.18		4,000	2,143	53.58

Table 10... Diploid-tetraploid matings in self-sterile multigerm sugarbeets.

Number of unfertilized, and fertilized normal and aborted ovules in diploid female parents pollinated by tetraploids.

Mating N	Matings	50 fruits per plant		
		Ovules		
		Unferti- lized Number	Fertilized Normal Number	Aborted Number
1	2n U.S. 75-6 x 4n 601-1	22	19	12
2	2n 112-10 x 4n 601-2	37	27	14
3	2n 112-8 x 4n 601-3	36	19	15
4	2n 112-7 x 4n 601-4	16	33	13
5	2n U.S. 75-1 x 4n 509-1	6	37	29
6	2n U.S. 75-2 x 4n 340-1	20	32	13
7	2n U.S. 75-3 x 4n 342-1	27	29	24
8	2n U.S. 75-4 x 4n 601-5	36	37	13
9	2n U.S. 75-5 x 4n 342-2	11	29	20
10	2n 112-1 x 4n 509-2	25	32	43
11	2n 112-2 x 4n 601-6	20	61	10
12	2n 112-4 x 4n 509-3	45	26	22
13	2n 112-6 x 4n 509-4	42	45	6
14	2n 112-105 x 4n 401-105	29	50	59
15	2n 112-107 x 4n 401-107	60	21	51
16	2n 112-110 x 4n 340-110	21	68	17
17	2n 112-106 x 4n 4-602-106	19	56	40
18	2n 112-108 x 4n 401-108	4	43	57
19	2n 112-109 x 4n 342-109	26	6	85
20	2n 112-116 x 4n 401-116	17	73	35
21	2n 112-111 x 4n 342-111	16	35	85
22	2n 112-9 x 4n 601-7	29	13	9
23	2n 112-3 x 4n 509-5	49	24	31
24	2n 112-115 x 4n 340-115	73	52	30
25	2n 112-113 x 4n 340-113	42	16	67
26	2n 112-112 x 4n 342-112	25	68	59
27	2n 112-120 x 4n 340-120	56	17	53
Total		809	968	912

Grand total ovules 2,689

Total fertilized
ovules 1,880

Percent from
Grand Total 30.09

Percent from
fertilized ovules 51.49 48.51

Total fruits 1,350

Table 11 ... Tetraploid-diploid matings in self-sterile multigerm sugarbeets.

Number of unfertilized, and fertilized normal and aborted ovules in tetraploid female parents pollinated by diploids.

Mating n	Matings	50 fruits per plant		
		Ovules		
		Unferti- lized	Fertilized Normal	Aborted
1	4n 601-1 x 2n U.S. 75-6	10	38	3
2	4n 601-2 x 2n 112-10	19	24	18
3	4n 601-3 x 2n 112-8	6	42	2
4	4n 601-4 x 2n 112-7	15	35	2
5	4n 509-1 x 2n U.S. 75-1	20	26	4
6	4n 340-1 x 2n U.S. 75-2	32	31	4
7	4n 342-1 x 2n U.S. 75-3	13	35	11
8	4n 601-5 x 2n U.S. 75-4	8	40	2
9	4n 342-2 x 2n U.S. 75-5	13	28	25
10	4n 509-2 x 2n 112-1	11	30	9
11	4n 601-6 x 2n 112-2	35	32	3
12	4n 509-3 x 2n 112-4	23	30	2
13	4n 509-4 x 2n 112-6	18	26	6
14	4n 401-105 x 2n 112-105	25	57	56
15	4n 401-107 x 2n 112-107	9	64	31
16	4n 340-110 x 2n 112-110	15	50	18
17	4n 602-106 x 2n 112-106	22	72	24
18	4n 401-108 x 2n 112-108	37	54	44
19	4n 342-109 x 2n 112-109	54	58	16
20	4n 401-116 x 2n 112-116	101	54	7
21	4n 342-111 x 2n 112-111	14	87	2
22	4n 601-7 x 2n 112-17	19	23	7
23	4n 601-8 x 2n 112-11	26	37	8
24	4n 601-9 x 2n U.S. 75-9	21	27	2
25	4n 601-10 x 2n U.S. 75-7	13	42	2
26	4n 340 x 2n 112-114	27	47	9
Total		606	1,089	317
Grand Total Ovules		2,012		
Total fertilized Ovules		1,406		
Percent from grand total ovules		30.12		
Percent from fertilized ovules		77.45 22.55		
Total fruits		1,300		

But a considerable difference was observed in percent of normal and aborted ovules depending on whether the female parent was a diploid, or a tetraploid. Although the number of normal and aborted ovules varied in different crosses, the summarized data indicated the advantage of using tetraploid plants as female parents. Tetraploids pollinated by diploid beets produced 77.45% normal and 22.55% aborted ovules, whereas the diploids pollinated by tetraploids had only 51.49% normally developed ovules and 48.51% aborted ovules. The difference is highly significant: t calculated equals 113.51 against t tabulated 2.008 at 0.05, and 2.678 at 0.01.

Presence of unfertilized ovules in the multigerm seedball does not permit determination of the number of viable and aborted ovules by the means of fruit germination. A fruit containing 2 unfertilized and 1 normal ovule, and a fruit having 1 unfertilized, 1 normal, and 1 aborted ovule may each give 1 sprout. For this reason the multigerm fruits obtained in reciprocal crosses were not tested for germination.

In the reciprocal diploid-tetraploid monogerm crosses, 50 fruits from each diploid and tetraploid plants were examined for the number of normal and aborted ovules and 50 fruits were used for germination. In the monogerm beets only the flowers containing fertilized ovules develop into fruits. The number of sprouts obtained indicates the number of viable monogerm fruits (also ovules).

The reciprocal crosses in the monogerm beets showed the same appearances as the reciprocal crosses in the multigerm beets. The tetraploid parents produced 87.85% normal ovules and 12.15% aborted ovules. The fruits of diploid parents contained 78.05% normal ovules and 21.95% aborted ovules (Table 12). Difference in percent of normal and aborted ovules developed on diploid and tetraploid parental plants is significant. The value of t calculated for normal, and also for aborted ovules, is 124.32 against t tabulated 1.994 at 0.05 and 2.648 at 0.01. It should be noticed that the abortion of ovules was lower in the monogerm than in the multigerm plants, and more viable ovules were produced by the monogerm than by the multigerm tetraploids.

The triploid monogerm fruits, collected from tetraploid parents, germinated better than the triploid fruits from diploid parents. The tetraploid plants gave 55% and the diploid plants 45% of sprouts. Difference is significant. The value of t calculated is 75.81, and the value of t tabulated is 1.994 at 0.05 and 2.648 at 0.01. The monogerm tetraploids showed the same tendency to produce more viable triploid fruits than the monogerm diploids. However, the difference in fruit germination was not as great as the difference in percent of normal and aborted ovules produced by diploid and tetraploid plants. Percent of fruit germination is always lower than percent of normal ovules observed, because some ovules that appear normal at the time of examination may lose their viability by harvest time. A comparatively low fruit germination in this experiment could be influenced by infection of stecklings used by virus yellow (Table 13).

Table 12 ... Diploid-tetraploid reciprocal matings in self-sterile monogerm sugarbeets

Number of normal and aborted ovules in diploid female parents pollinated by tetraploid, and in tetraploid female parents pollinated by diploids.

Mating N	Matings	50 fruits per plant			
		Diploid female parent		Tetraploid female parent	
		Ovules		Ovules	
		Normal Number	Aborted Number	Normal Number	Aborted Number
1	2n 15 x 4n 15	38	12	50	0
2	2n 15 x 4n 4-570	42	8	46	4
3	2n 15 x 4n 15	36	14	40	10
4	2n 15 x 4n 15	38	12	48	2
7	2n 4-568 x 4n 15	24	26	48	2
8	2n 4-568 x 4n 4-570	40	10	38	12
9	2n 4-568 x 4n 4-570	44	6	50	0
10	2n 4-568 x 4n 15	42	8	42	8
12	2n 4-568 x 4n 4-570	40	10	46	4
15	2n 15 x 4n 4-570	34	16	48	2
16	2n 4-568 x 4n 15	30	20	46	4
17	2n 15 x 4n 15	46	4	46	4
18	2n 15 x 4-4-570	42	8	50	0
19	2n 4-568 x 4n15	44	6	46	4
21	2n 4-568 x 4n Klein	48	2	34	16
22	2n 15 x 4n 4-570	30	20	36	14
25	2n 15 x 4n 15	44	6	48	2
27	2n 4-568 x 4n Klein	48	2	26	24
28	2n 4-568 x 4n Klein	50	0	40	10
29	2n 15 x 4n 15	48	2	46	4
31	2n 4-568 x 4n 4-570	30	20	50	0
32	2n 4-568 x 4n 4-570	42	8	46	4
33	2n 15 x 4n 15	36	14	44	6
34	2n 4-568 x 4n 4-570	42	8	44	6
35	2n 4-568 x 4n 4-570	26	24	50	0
36	2n 4-568 x 4n 4-570	42	8	44	6
37	2n 4-568 x 4n 4-570	42	8	50	0
38	2n 4-568 x 4n 4-570	46	4	44	6
40	2n 15 x 4n Klein	30	20	34	16
41	2n 15 x 4n 15	36	14	42	8
42	2n 15 x 4n 15	46	4	44	6
43	2n 15 x 4n Klein	28	22	44	6
44	2n 4-568 x 4n 4-570	26	24	48	2
45	2n 15 x 4n 15	50	0	46	4
46	2n 4-568 x 4n 4-570	38	12	40	10
47	2n 4-568 x 4n 4-570	38	12	36	14
48	2n 4-568 x 4n 4-570	38	12	48	2
Total		1,444	406	1,628	222
Grand Total		1,850		1,850	
Percent		78.05	21.95	87.85	12.15

Table 13... Diploid-tetraploid reciprocal matings in self-sterile monogerm sugarbeets.

Fruit germination in diploid female parents pollinated by tetraploids and in tetraploid female parents pollinated by diploids.

Mating N	Matings	50 fruits per plant	
		Diploid female parent	Tetraploid female parent
		Sprout obtained	
		Number	Number
1	2n15 x 4n15	19	19
5	2n15 x 4n 4-570	33	21
7	2n15 x 4n15	18	22
9	2n15 x 4n15	1	42
11	2n 4-568 x 4n 4-570	4	33
13	2n15 x 4n 4-570	10	23
15	2n 4-568 x 4n15	30	40
17	2n 4-568 x 4n 4-570	36	34
19	2n-4-568 x 4n 4-570	23	23
23	2n 4-568 x 4n15	38	37
25	2n 4-568 x 4n15	34	28
27	2n 4-568 x 4n 4-570	13	38
29	2n15 x 4n 4-570	5	25
31	2n15 x 4n15	5	20
33	2n15 x 4n 4-570	10	21
35	2n 4-568 x 4n15	5	20
37	2n15 x 4n15	42	42
41	2n15 x 4n 4-570	12	15
43	2n 4-568 x 4n15	4	16
45	2n 4-568 x 4n Klein	34	41
47	2n 4-568 x 4n Klein	47	31
49	2n15 x 4n 4-570	35	11
51	2n15 x 4n15	11	21
53	2n 4-568 x 4n15	28	47
59	2n15 x 4n15	45	49
61	2n 4-568 x 4n Klein	45	15
65	2n 4-568 x 4n Klein	43	19
67	2n 4-568 x 4n Klein	43	37
69	2n15 x 4n15	24	19
71	2n15 x 4n 4-570	18	12
79	2n 4-568 x 4n 4-570	28	39
81	2n 4-568 x 4n 4-570	8	25
85	2n15 x 4n15	26	36
89	2n 4-568 x 4n 4-570	4	32
91	2n 4-568 x 4n 4-570	8	23
93	2n 4-568 x 4n 4-570	32	31
95	2n 4-568 x 4n 4-570	25	35
103	2n 4-568 x 4n 4-570	26	38
109	2n15 x 4n15	32	29
111	2n15 x 4n Klein	40	45
Total		944	1,154
Grand Total		2,098	
Percent		45.00	55.00

DISCUSSION AND CONCLUSION

Data of fruit germination in male-sterile lines and populations pollinators are in good agreement with those of the previous study of the effect of fertilization and ovule development. A statistical analysis of the data obtained for ovule development and fruit germination indicates that both parents, male and female, are responsible for the viability of fruits; the pollinators, however, being more responsible for the differences in viability between diploid and triploid fruits. The results obtained may be discussed from the point of view of 3 conceptions: 1/ effect of three-allelic gene combinations, 2/ unbalanced genomes in different tissues of developing fruit, and 3/ aneuploidy.

The triploid hybrid populations (also triploid embryos in the fruits) derived from reciprocal crosses of $2n \times 4n$ plants, will have the same genic composition (if selective fertilization is not taken into account). Therefore, differences in the viability of triploid fruits, grown on diploid and on tetraploid female parents, cannot be explained by the influence of genes in triploid combinations. If even some genes, present in 3 alleles may cause a certain disturbance in fruit development, the general process of fruit development in polyploids cannot be attributed to their action.

Differences in the viability of triploid fruits, developed on diploid and tetraploid female plants, is also not explainable on the basis of unbalanced genome ratio. According to the hypothesis of unbalanced genomes only the crosses $2n \times 2n$ and $4n \times 4n$, in which the genomes in the endosperm and in the maternal tissue of the seeds are in 3:2 ratio (balanced ratio) produce viable seed. An increase of this ratio to 4:2, or a decrease to 5:4 (unbalanced ratios) results in failure of seed. Operation of this hypothesis would prevent the obtaining viable triploid seed. The hypothesis of unbalanced genomes is not acceptable for the following reasons: 1/ on every plant in any mating were obtained viable and inviable triploid fruits which had the same genome balance; 2/ At different genome balances - in $3n$ fruits from $2n \times 4n$ crosses - 4:2 ratio (36 chromosomes in the endosperm: 18 chromosomes in maternal tissue), and in $3n$ fruits from $4n \times 2n$ crosses - 5:4 ratio (45 chromosomes in the endosperm : 36 chromosomes in the maternal tissue) the viable and inviable triploid fruits were obtained. No genome balance provided for obtaining of all viable, or all inviable fruits.

A comparison of fruit development and fruit germination in different matings led to conclusion that, the aneuploidy not the polyploidy reduces the viability of the tetraploid and triploid fruits in polyploid crosses. Many male-sterile plants produced viable triploid fruits with excellent germination, while the other fruits on the same plants were inviable. Obviously, fertilization by pollen grains carrying an aneuploid chromosomes set, caused some disturbances in the endosperm, or embryo development which led to the abortion and inviability of seed.

Difference in sexual reproduction of tetraploids compared to diploids is based on the outline of meiosis in these 2 groups of plants. Irregulari-

ties of tetraploid meiosis: formation of multivalent associations and irregular chromosomes distribution in the 1 meiotic division leads to formation of pollen grains and egg cells with aneuploid chromosome set. Every pollen mother cell with irregular distribution of chromosomes in the first division gives a tetrad of microspores - all with aneuploid nuclei. If the irregular chromosome distribution occurs in 50% of PMCs the number of euploid and of aneuploid pollen grains will be equal in the tetraploid population. Any increase of the number of PMCs with irregular chromosome distribution will lead to an excess of aneuploid pollen grains. For instance, if in 6 of 10 PMCs the chromosome distribution is irregular, they will produce in monogerm beets 24 (6×4) aneuploid pollen grains. The remaining 4 microspores will give 16 (4×4) euploid pollen grains. The multigerm populations produce about 3 times more male and female gametes than the monogerm populations, therefore the quantity of male and female gametes with irregular chromosome distribution should be larger in the multigerm populations. Using the same ratio of regularly and irregularly dividing PMCs, we may assume that 18 irregularly dividing PMCs will produce in the multigerm beets 72 (18×4) aneuploid pollen grains. The remaining 12 PMCs will give 48 (12×4) euploid pollen grains (Table 14). In many tetraploid plants, percent of PMCs with irregular meiosis will be undoubtedly beyond 60, but a certain quantity of aneuploid pollen grains will always be present in tetraploid populations, and their quantity will always be bigger in the multigerm populations. In the tetraploid populations, gametes carrying the number of chromosome deviating from the diploid set are low in viability, therefore, some egg cells remain unfertilized and decrease the fertility of tetraploids. Fertilization in the open pollinated populations by pollen grains with deviating chromosome number contribute to abortion of fertilized ovules. A certain percent of aborted ovules should always be present in tetraploids. Indeed, examination of ovule development indicated that tetraploid open pollinated populations differ from the diploid populations mainly by the high percent of unfertilized ovules and slightly exceed them in percent of fertilized aborted ovules. The F value for a significant difference between tetraploid and diploid populations in percent of unfertilized ovules was 42.32, and in percent of aborted ovules 5.03, against F tabulated 4.18 and 7.60 at 5% and 1% levels. Germination of tetraploid fruits was also lower than germination of diploid fruits, but the significance of the difference in viability of diploid and tetraploid fruits was not high: F equaled 4.55, against F tabulated 4.18 (5%), and 7.60 (1%).

Individual tetraploid populations differ in the grade of irregularities in meiosis. The more irregular the distribution of chromosomes in meiotic division, the lower the fertility of the population, and the higher the manifestation of gamete sterility and ovule abortion. The monogerm tetraploid population, SLC 15- m_4 , had more aborted ovules and a lower percent of fruit germination (67.60%) than the other monogerm tetraploid population, Klein E- m_4 , in which 81.20% of fruits germinated. Of 2 tetraploid multigerm populations, the population 4-900- M_4 had much more aborted ovules than the population 4-601- M_4 , and was also lower in fruit viability. In the population

4-900-M₄ 68.09% of the locules germinated, and in the population 4-601-M₄ 76.48% of the locules germinated.

Because of the larger number of aneuploid gametes in multigerm beets, the manifestations of gamete sterility should be stronger in the multigerm tetraploid populations. Indeed, percent of unfertilized ovules was higher in the tetraploid multigerm (37%) than in the monogerm (27%) populations.

Biological differences of multigerm and monogerm populations were also reflected in the progenies produced by them when used as pollinators. Triploid fruits developed on diploid male-sterile plants pollinated by monogerm tetraploids did not differ significantly in percent of aborted ovules from the diploid fruits. Germination of triploid fruits obtained from monogerm pollinators was only slightly lower than germination of diploid fruits. Different populations may produce, of course, different effect as pollinators, and it is possible that some of tetraploid monogerm pollinators will produce triploid fruits of almost the same vitality as that of diploid fruits. Triploid fruits obtained from pollination by tetraploid monogerm population Klein E-m₄ did not differ in germination (69.28%) from diploid fruits derived from diploid monogerm pollinators (70.88%).

The multigerm tetraploid populations used as pollinators for diploid male-sterile lines increased ovule abortion and lowered the viability of triploid fruits. Triploid fruits obtained in such matings differed significantly in percent of aborted ovules from diploid fruits. Germination of triploid fruits derived from pollination by multigerm tetraploid populations was the lowest in the experiment (55.38%). Especially low was the germination of triploid fruits produced by the pollinator, 4-900-M₄. Both tetraploid and triploid fruits produced by this population had low vitality.

Different viability of triploid fruits in reciprocal $2n \times 4n$ crosses, and the advantage of using tetraploid female parents is caused by the high reduction of aneuploid female gametes in tetraploids. In every plant the number of female gametes derived from 1 megaspore is 3 times less than the number of male gametes produced by 1 pollen mother cell, since only 1 embryo sac develops after meiosis in the megaspore mother cell, whereas each pollen mother cell produces 4 microspores. From a triad resulting in beets after meiosis in the megaspore only the macrospore most distant from the micropile develops into an embryo sac. If 6 of 10 megaspores divide irregularly (as we assumed for PMCs) only 6 aneuploid embryo sacs (and 6 aneuploid egg cells) will develop in the monogerm plants. The regularly dividing 4 megaspores will give 4 euploid embryo sacs.

In the multigerm beets (in which 3 flowers and 3 ovules develop in each inflorescence unit) correspondingly 18 irregularly dividing megaspores will produce 18 aneuploid egg cells. Twelve euploid egg cells will develop from 12 regularly divided megaspores (Table 14).

Table 14... Expected number of aneuploid and euploid pollen grains and egg cells in tetraploid monogerm and multigerm beets at 6 of 10 pollen mother cells and megaspores with irregular meiosis.

4n Monogerm beets				4n Multigerm beets			
Pollen grains		Egg cells		Pollen grains		Egg cells	
Aneuploid	Euploid	Aneuploid	Euploid	Aneuploid	Euploid	Aneuploid	Euploid
N u m b e r		N u m b e r		N u m b e r		N u m b e r	
24	16	6	4	72	48	18	12

Besides of the reduced number of aneuploid female gametes, the central nucleus, from which the endosperm develops, is formed in the aneuploid embryo sac by fusion of 2 aneuploid nuclei. Function of such central nuclei with increased aneuploidy is highly reduced, and that contributes to the higher sterility of aneuploid female gametes.

Because of the higher elimination of aneuploid female gametes, the tetraploid plants pollinated by the haploid pollen grains of diploid beets produce more viable and less aborted triploid fruits than the diploid plants pollinated by tetraploids, many pollen grains of which carry an irregular chromosome number. Both multigerm and monogerm beets manifested this appearance, but the difference between reciprocal crosses was greater in multigerm beets. The amount of aneuploid pollen grains and egg cells is bigger in multigerm beets, therefore, the abortion of ovules is higher and viability of triploid fruits is lower in multigerm crosses. Self-sterile monogerm beets produced more viable triploid fruits in reciprocal crosses than the multigerm beets; tetraploid monogerm pollinators did not decrease the viability of triploid fruits to the extent that the multigerm tetraploid did.

Gamete sterility and zygote sterility (ovule abortion) is the mechanism by which tetraploids clean up themselves to maintain their "status quo" as tetraploids. Naturally, the same processes decrease the viability of triploid fruits.

Analyzing the data concerning fertility of diploid male-sterile lines, we may discuss their fertility in diploid matings. Male-sterile lines pollinated by diploid monogerm and multigerm populations contained in the average 23.69% of unfertilized ovules. The unfertilized ovules occur in male-sterile lines mainly in a result of unsufficient pollination caused by lack of simultaneous flowering of male-sterile plants and pollinators. Flowers with unfertilized ovules do not develop into fruits in monogerm beets and cannot influence the viability of fruits, but their large number may decrease the yield of seed. The reason for occurrence of aborted ovule in diploid matings is unknown, probably the embryological study will elucidate the causes of their appearance.

A grade of fruit germination is the best characteristic of the grade of fertility of male-sterile line. Data obtained showed that fertility of male-sterile lines is not perfect even in diploid matings. In all matings the viability of fruits developed on male-sterile plants was lower than the viability of fruits in the open pollinated self-sterile populations grown in the same conditions on the same isolations. Some male-sterile lines were higher, some lower, in fruit viability, but no line was uniform in the grade of fertility of individual plants within the line. In all male-sterile lines some plants produced highly viable fruits, which germinated 90%, and over. Fruits from the other plants had intermediate percents of germination, and some plants produced fruits which germinated only 10 to 20 percent.

Such low in fertility plants decrease the grade of fertility of male-sterile lines. If the viability of diploid fruits itself is not sufficiently high, or it hardly reaches the level of germination required for commercial planting, then any little minus deviation caused by tetraploid pollinators will decrease the fruit viability below the level at which they could be used for commercial purposes. Improvement of fertility in the male-sterile lines is important for diploid and for polyploid crosses.

Presence of high and low fertile plants within male-sterile lines indicates that some genetic processes are responsible for their occurrence. It is almost obvious that male-sterile cytoplasm itself does not decrease the fruit viability, because some male-sterile plants produce highly viable fruits. The most probable cause is the segregation of some genes within the male-sterile lines that decreased the fruit viability. Variation in viability of fruits within a plant in diploid matings is also an indication of gene segregation. The possibility of a lethal effect of some genes in reaction with male-sterile cytoplasm is also not excluded. The extent of the influence of inbreeding on fertility of male-sterile lines must be determined by the corresponding experiments. Observation made in this experiment did not indicate a significant difference in fertility between inbred and hybrid male-sterile lines. Male-sterile lines differ in the grade of fertility from self-sterile plants and this difference is genetically controlled.

The following measures may be recommended, at present time, for improvement of male-sterile lines: 1/ selection for fruit viability in male-sterile lines and in their equivalent pollinators; 2/ hybridization of O-type inbreds with other O-type monogerm inbreds and with different monogerm and multigerm populations and selection in the monogerm hybrids for fruit viability to accumulate the genes responsible for better fertility. The sugarbeet has not been selected for viability of germs. The multigerm fruit does not permit such selection. The shift of the sugarbeet industry from multigerm to monogerm beets requires selection for increased viability of monogerm fruits. All agricultural methods concerning the time of planting and harvesting the seed beets, application of fertilizers at certain stages of plant growth, pinching the branches, etc., methods which may improve the viability of normally developing ovules, are welcomed. But no such methods can improve the genetic constitution of male-sterile lines, neither can they restore the sterile gametes or zygotes (aborted ovules) which died a long time before seed harvest. Fruit viability in diploid and polyploid crosses is determined by genetic structure of plants, therefore, hybridization and selection are necessary to change the genetic structure in the desirable direction.

The following suggestions may be indicated for the improvement of viability of triploid fruits: 1/ the female parent should be monogerm, because of reduced aneuploidy in the monogerm beets. The fertility of

diploid male-sterile lines should be improved. Whether the tetraploid male-sterile lines will give better results than the diploid can be determined only by further experimentation. If self-sterile beets are used in production of polyploid varieties- especially if multigerm, the female parent should always be a tetraploid. Aneuploidy is highly reduced in such crosses. 2/ What concerns the pollinators - it is highly desirable to use as pollinators the tetraploid monogerm populations, which produce the triploid fruits of almost the same viability as the diploid fruits. The tetraploid monogerm highly productive populations should be available for this purpose. If the multigerm tetraploid populations are used as pollinators, such populations should be selected which give a minimum decrease in the viability of triploid fruits.

But the basic improvement in the breeding of triploid and tetraploid varieties, besides improvement of fertility in male-sterile lines, will consist in producing tetraploid populations with lower numbers of multivalent associations and lower grades of aneuploidy. Development of methods for an effective selection in decreasing aneuploidy is highly desirable. Triploid, and also some tetraploid hybrids, are highly productive and a successful development of polyploid hybrids will present a distinct advancement in sugarbeet breeding.

BREEDING FOR RESISTANCE TO SUGARBEET
NEMATODE HETERODERA SCHACHTII SCHM.

D. L. Doney and E. D. Whitney

A. Breeding and Selection

1. Evaluation of Nematode Cyst Counting as a means of
Screening for Nematode Resistance

A technique for counting nematode cysts on the periphery of the soilball has been developed (Annual Report 1966). A number of nematode tolerant selections were tested against their parents for number of emerging female cysts as a measure of resistance. No differences were found between the selections and parents (Annual Report 1966). However, it was theorized that different levels of qualitative resistance might be developed even though no differences were found between the present selections and their parents.

To determine if different levels of resistance could be developed by selecting on the basis of nematode cyst counts, a significant genotypic variance must exist for this character. Therefore, a number of very heterozygous lines of different origin were tested.

Materials and Methods

Twelve heterozygous populations of different origin (table 1) were tested for genotypic variance and mean differences for number of emerging female cysts on the soilball periphery.

Testing for number of emerging female cysts consisted of inoculating plants in 85 and 155 ml plastic vials with surface sterilized larvae and counting white female cysts on the soilball periphery 4 weeks after inoculation. Larvae were inoculated on the soil surface around the plant. Plants were inoculated when good root growth was observed through the plastic vials. Plants in 85 ml vials received 1500 larvae and plants in 155 ml vials received 3000 larvae. Several tests were conducted on each population. A uniform hybrid and a homozygous line were included in all tests for an estimate of the environmental variation. Genotypic variances were estimated by subtracting the estimated environmental variance from the total phenotypic variances. The F test for homogeneity of variance was computed to test for significant genotypic variance. A completely randomized block design was used in all tests.

Table 1. Code or name, source, and description of test material for cyst counts.

Variety or Line	Source	Description
F ⁸ -554H1	USDA (J. McFarlane)	Uniform hybrid*
C5600	USDA (B. Hammond)	Homozygous line*
GW 350	Great Western Sugar Co.	Very heterozygous
C877	Great Western Sugar Co.	Very heterozygous
C878	Great Western Sugar Co.	Very heterozygous
B888	Great Western Sugar Co.	Very heterozygous
B889	Great Western Sugar Co.	Very heterozygous
54-604-0	American Crystal Sugar Co.	Aphanomyces selection
60-604-0	American Crystal Sugar Co.	Aphanomyces selection
56-gH #3-M-1	American Crystal Sugar Co.	Nematode selection
Tetra-Tri-Polanowice	USDA (G. Coe)	European origin
Budapest Poly Beta 2	USDA (G. Coe)	European origin
Budapest Poly Beta 4	USDA (G. Coe)	European origin
Poly Mono Poli-0	USDA (G. Coe)	European origin
A. J. Poli 2	USDA (G. Coe)	European origin
Buszcynski P. Poly	USDA (G. Coe)	European origin

* = Used to estimate environmental variances.

Results

The mean number of cysts per plant for each entry in each test is shown in tables 2 and 3. There were large differences between tests, therefore, a rank comparison test was conducted on each pair of tests rather than computing the overall means. The ranks of each entry and Spearman's rank correlation coefficient are shown for each test in tables 2 and 3. In no pair of tests was there a significant correlation between the ranked means for number of cysts per plant.

There were significant differences within tests but there was also a significant varieties times tests interaction. This indicates why the ranked means were not correlated. The only variety that was consistent from test to test was C5600, which was high in all tests (table 2).

The variances for each entry in each test, the estimated environmental variance and the total phenotypic variance for the heterozygous populations are shown in tables 4 and 5. In no test was there a significant total genotypic variance. However, when testing individual entries, five varieties had a significant genotypic variance in one test. No variety had a significant genotypic variance in more than one test, even though they were tested two and three times each.

Discussion

Sufficient genotypic variation for number of emerging female cysts was not found in these lines and varieties to warrant selection in these lines by cyst counts. This study points out the difficulty of selecting for small differences by counting cysts. If there are genetic differences, they are small and the large environmental variation masks their effect, thus making variants unidentifiable. Much work has been done to reduce this large environmental variation, but it is still large. Two factors that are known to effect this variation are temperature and moisture. If this variation is to be reduced still further, more elaborate systems are needed to give more accurate control of these two factors.

2. Selection for Yield Under Nematode Conditions in the Greenhouse

Greenhouse data from experiments conducted in 1966 indicated that some progress could be achieved by selecting for yield under nematode conditions in the greenhouse.

During the summer of 1967 two selection groups of divergent origin were set up. Each group consisted of 5 heterozygous lines. Plants of each line were grown in cold frames in eight inch pots and 50,000 nematode larvae added to each pot over a period of 5 weeks. At the end of the growing season selections were made from the better lines for subsequent crossing and seed increase.

Table 2. Mean number of cysts on the soilball periphery, rank and Spearmans rank correlation coefficient.

Variety or Line	708g1		708g2		708g3	
	No.	Rank	No.	Rank	No.	Rank
F58-554H1	9.40b	8	13.64b	5	69.46ab	2
C5600	15.70a	1	18.50a	2	74.03a	1
GW 359	11.10b	3	18.86a	1	45.95d	8
C877	8.50b	9	14.48b	3	53.50cd	5
C878	11.30b	2	--		--	
B888	10.70b	4	13.65b	6	67.19ab	3
B889	9.70b	7	14.23b	4	57.87c	4
54-604-0	10.60b	5	11.60b	8	50.97cd	7
60-604-0	10.40b	6	13.38b	7	52.70cd	6
Spearmans rank	708g1 x 708g2		708g2 x 708g3		708g1 x 708g3	
Correlation coef.	= .13		= .08		= .01	

Note = Any two means followed by the same letter are not significantly different at $p = .05$.

Table 3. Mean number of nematode cysts on the soilball periphery, rank and Spearmans rank correlation coefficient.

Variety or line	708d1		708d2	
	No.	Rank	No.	Rank
F58-554H1	19.31c	8	21.67ab	7
C5600	35.40b	4	27.17a	1
Tetra-Tri-Polanowice	43.30a	1	25.22a	5
Budapest Poly Beta 2	25.00c	6	26.80a	2
Budapest Poly Beta 4	40.30ab	2	25.94a	4
A. J. Poli 2	19.70c	7	24.59a	6
Buszcynski P. Poly	35.50b	3	26.01a	3
Poly Mono Poli-0	19.20c	9	--	
56-gH #3-M-1	29.50b	5	18.80b	8
Spearmans rank correlation coefficient = .33				

Note = Any two means followed by the same letter are not significantly different at $p = .05$.

Table 4. Phenotypic ($\text{Var}_e + \text{Var}_g$) and estimated environmental (Var_e) variances.

Variety or Line	708g1	708g2	708g3
F58-554H1	77.8	1,678	76.4
C5600	145.5	1,140	171.0
GW 359	156.5	746	76.1
C877	92.4	1,214	60.2
C878	--	--	141.5
B888	67.1	1,251	118.6
B889	86.3	841	90.6
54-604-0	93.7	903	197.8
60-604-0	95.1	975	99.7
Var_e	112.6	1,409	123.7
$\text{Var}_e + \text{Var}_g$	94.0	1,081	104.0

Table 5. Phenotypic ($\text{Var}_e + \text{Var}_g$) and estimated environmental (Var_e) variances.

Variety or Line	708d1	708d2
F58-554H1	218	151
C5600	359	311
Tetra-Tri-Polanowice	209	545*
Budapest Poly Beta 4	377	480*
Poly Mono Poli-0	---	175
Budapest Poly Beta 2	414*	332
A. J. Poli 2	297	319
Buszcynski P. Poly	369	608*
56-gH #3-M-1	166	800*
$\hat{\text{Var}}_e$	288	231
$\hat{\text{Var}}_e + \hat{\text{Var}}_g$	284	377

* = Significant genotypic variance at $p = .05$.

3. Inoculating Seedlings with Large Quantities of Nematode Larvae

It was noted in earlier studies that inoculations of large quantities of nematode larvae on small sugarbeet seedlings caused considerable retardation and sometimes death. These observations were obtained under rather sterile conditions, i.e., sterilized containers, soil, seed, and surface sterilized nematode larvae. However, since they were grown in the greenhouse they were susceptible to air contaminants.

Earlier studies also pointed out that heavy nematode infections after the beets were well established resulted in much smaller losses than heavy infections in the early seedling stage.

These nematode effects are probably a function of the number of nematode larvae invasions to the total fibrous roots. These observations suggested a selection scheme for seedling vigor or tolerance to nematode invasion. A program has been initiated for this purpose. The essential steps of this program are:

- (1) Seeds are planted in small 85 ml vial.
- (2) Upon emerging, plants are inoculated with approximately 6,000 nematode larvae plus two succeeding inoculations of 6,000 surface sterilized larvae at 12 hour intervals for a total of 18,000 larvae.
- (3) Plants begin showing symptoms several days after inoculation. Approximately two weeks after inoculation the maximum effect is reached when the mortality rate reaches between 60-80%. Recovery proceeds slowly after this. At this time selections are made for further testing.
- (4) Selections are further tested in heavy infested nematode soil for two to three more cycles before being thermally induced for seed production and subsequent crossing. Several thousand seedlings have been screened and selections made. This work is being pursued rather vigorously at the present time.

4. Field Testing

- (a) 1967 Field Test.

Methods and Materials

During the winter of 1967 the nematode field plot was leveled to insure better irrigation and uniformity, therefore, additional nematode infested soil was added to each row prior to planting.

The 1967 field trial consisted of the 10 entries shown in table 6. A latin square design was used for planting. The trial was planted May 8, thinned June 1, and harvested October 30. Normal agronomic practices, such as cultivation, irrigation, and fertilization were carried out throughout the growing season.

Stand counts were made one week after thinning and roots counted at harvest time to determine the number of roots dying during this period of time. This was calculated as percent loss. At harvest time root weights were taken for all plots and sucrose percentages determined on four replicates chosen at random for each entry.

Results

The data for the 1967 field trial are shown in table 6.

The ranking of varieties that appeared in both the 1966 and 1967 field trials ~~was~~ in very close agreement. A significant correlation (.86) of the ranked means of these entries was obtained (Spearman's rank correlation coefficient).

In both years the selections 590-1, 590-9 and 592-1 were among the highest yielding. Whereas, the parents US 41 and S 2 and the commercial hybrid (US H7) were the low yielding entries. A selection obtained from G. C. Curtice (Acc 107) also performed very well and was among the top yielding entries.

Two entries from American Crystal Sugar Company yielded midway between the low and high yielding entries. These two entries had some Aphanomyces resistance.

In the early part of September, water was held from the field to measure the wilting resistance of the entries. Only one variety (54-604-0, an Aphanomyces resistant line) appeared to have some wilting resistance under these conditions.

Similarities between the 1966 and 1967 data were also found in the number of beets dying between thinning and harvest. In both years, US H7 had one of the best stands at thinning time, but had the highest percentage dying between thinning and harvest time.

Highly significant negative correlations were obtained between the loss of beets between thinning and harvest and yield. Significant correlations of similar magnitude were obtained in 1966 for the same correlations.

Several of these selections have consistently shown their superiority when grown in nematode infested fields.

(b) Pilot Field Study.

In an attempt to study field plot techniques, a pilot study was conducted to determine the effect of early nematode infection in the field.

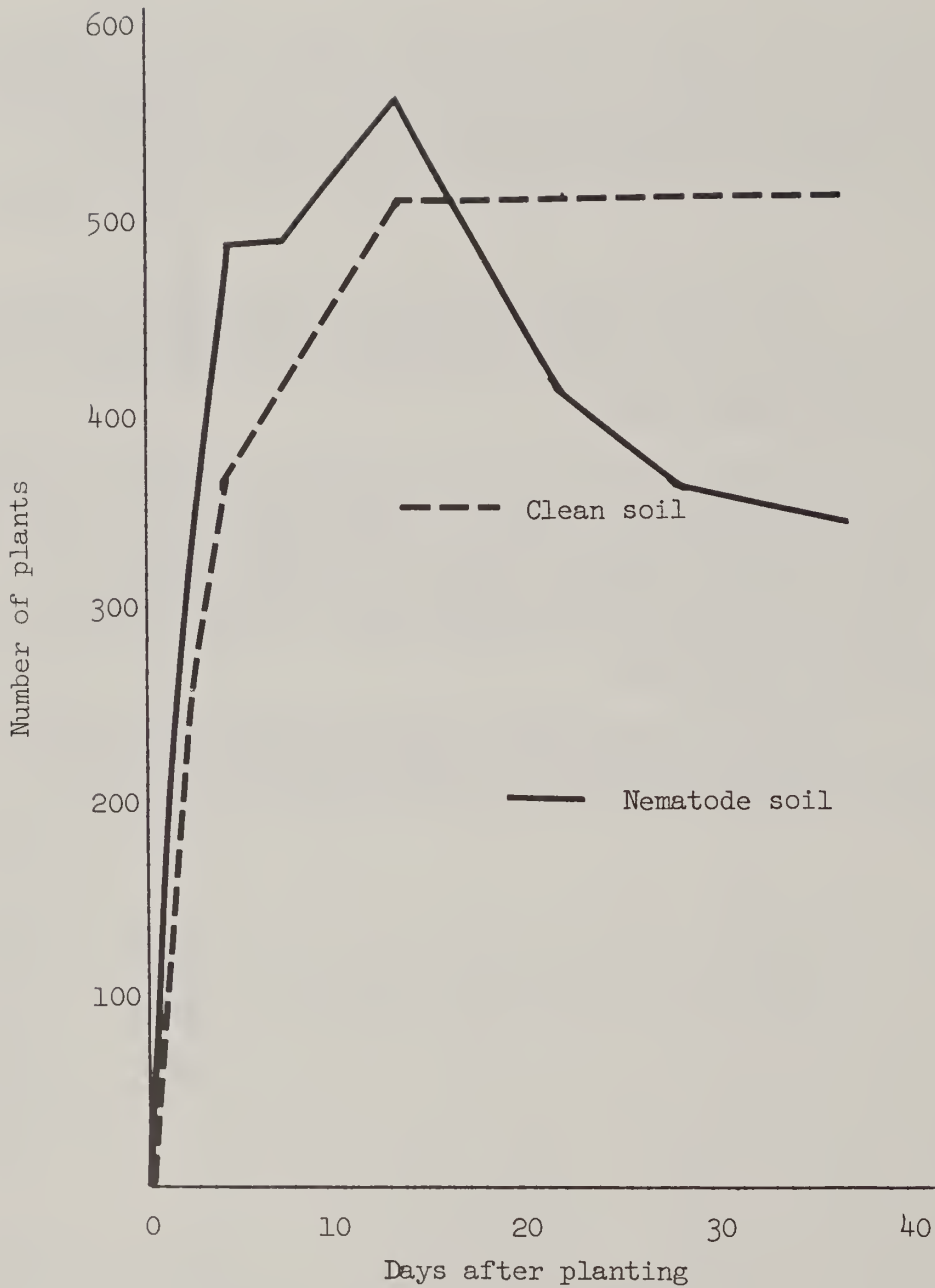
Two plots were planted in which heavy infested nematode greenhouse soil was added to one half of the rows. Seed of a uniform variety was planted one inch deep directly in the nematode soil. The remaining rows were planted at the same time at a depth of one inch also.

The first plot was planted June 29, 1967, and is shown in Figure I.

The rows closest to the adjoining plot had considerable natural nematode infestation. Rows that were clean of nematodes when the trial started but had nematode soil added were greatly retarded when compared to their healthy counter parts.

Test two was planted July 27, 1967 and shown in Figure II. This picture was taken on August 21, 1967. A dotted stake at the foot of a row indicates nematode soil was added prior to planting. As can be seen in Figure II, the nematodes caused a tremendous reduction in growth. Stands of beets were also reduced as shown in **Graph 1**. Plants in nematode treated rows emerged early, but many died soon after being attacked by nematodes.

This procedure is to be tested in a much larger trial in 1968 in an effort to obtain more precision in field testing for nematode resistance.



GRAPH I. Emergence and survival of seedlings in clean and nematode infested soil.



Fig. I.--Growth of sugarbeets as a result of: 1) Naturally infested nematode soil, 2) Nematode soil added to naturally infested soil, 3) Clean soil, 4) Nematode soil added to clean soil.



Fig. II.--Sugarbeet growth as a result of adding nematode infested soil. Dotted stake at the foot of a row indicates nematode infested soil was added.

B. Physiology of Nematode Infection

1. Chemical nature of Resistance - Amino Acids (conducted jointly with J. M. Fife)

The initiation of this study was reported in the 1966 report. In tests conducted in 1966 it was found that nematodes caused an increase in the concentration of certain amino acids in the fibrous roots of the sugarbeet, but caused no change in the concentration of these amino acids in Beta patellaris (a wild resistant species in which the nematode larvae invade but never mature).

The 1967 study had the following objectives:

(1) To determine if sufficient genotypic variation exists in the sugarbeet such that progress can be made by selection on the basis of amino acid concentration in nematode infected plants, and (2) To determine if the concentration of these amino acids in nematode infected plants is a measure of resistance.

Materials and Methods

Eleven different varieties, which included a uniform hybrid and a homozygous line for estimates of environmental variation, were selected for testing (table 7).

Sixty plants of each line were transplanted in 185 ml plastic vials in sterilized soil. Four weeks after transplanting 4,000 surface sterilized nematode larvae were added to 30 plants of each variety. A split plot design was used with treatments (nematodes vs no nematodes) as whole plots and varieties randomized completely as subplots.

Four weeks after inoculation the white female cysts around the soilball periphery were counted. The plants were then washed and weights taken on tap and fibrous roots. A sample of fibrous root from each plant was frozen for subsequent amino acid analysis.

Sterilized nematode larvae were hatched and surface sterilized by the method developed by Whitney (2). Concentration of amino acids was determined chromatographically (1) from expressed fibrous root juice. The concentration was calculated from the color intensity of ninhydrin-stair amino acids. Data were taken on aspartic acid, glutamic acid, and glutamine only.

Results

The F tests of the analysis of variance for the six types of data taken are shown in table 8. Varieties is the only line in the analysis of variance for nematode cyst counts.

Table 7. Source and description of genetic material tested

Variety or code	Source	Description
56-408	American Crystal Sugar Co.	nematode selection
28-1	USDA	nematode selection from US 41
US 41	USDA	open pollinated variety
590-1	USDA	nematode selection from S 2
S 2	Spreckels Sugar Co.	open pollinated variety
592-3	USDA	nematode selection from US 33
US 33	USDA	open pollinated variety
594-2	USDA	nematode selection from US 22
Acc 107	G. C. Curtice (England)	mixture of nematode selections
62-9134	USDA (R. Hecker)	uniform hybrid
C5600	USDA (B. Hammond)	doubled haploid - homozygous

A significant nematode effect (nematode vs healthy) was observed in all three amino acids, but not in tap root and fibrous root weights. Perhaps the reason for this lack of significant nematode effect in the tap and fibrous root weights was the short duration of the experiment. Significant differences between varieties were obtained for all types of data except nematode cyst counts.

A significant interaction (varieties x nematode effect) would indicate that there were both resistant and susceptible varieties in the test and the concentration of amino acids is a measure of resistance. A significant interaction was only found for fibrous root weight. Since all varieties were Beta vulgaris and susceptible, the first assumption did not hold and the assumption that the concentration of amino acids is a measure of resistance could not be tested.

Table 9 contains the estimated variances for the six characters measured for each variety along with the estimated total environmental and estimated total genotypic variances.

For every character a significant total genotypic variance was obtained except for nematode cyst counts. The total environmental variance was significantly larger in the nematode infected plants than in the healthy plants for the three amino acids and fibrous root weights. In addition, a significantly larger total genotypic variance was obtained in the nematode infected plants than in the healthy plants for aspartic acid, glutamine, and fibrous root weights.

In most of the varieties for most characters larger variances were found in nematode infected plants. Three varieties (Acc 107, 28-1, and 594-2) appeared to be the more variable varieties. A significant genotypic variance was obtained in these three varieties for most of the characters measured.

The simple correlations between each pair of characters for each variety was also computed (tables 10, 11, and 12). Nematode counts were unrelated with most characters measured (table 10), except with tap root weights where a total significant correlation of .23 was obtained. However, in variety 594-2 a relationship between nematode cyst counts and the other characters measured appears to exist.

There were good significant correlations (table 11) between the amino acids. The best correlations were found between glutamic acid and glutamine. When each correlation was computed for healthy and nematode infected plants, a larger correlation was obtained in the infected plants in nearly every pair of correlations.

Table 8. F tests of analysis of variance for tap root weight, fibrous root weight, nematode counts, and concentration of aspartic acid, glutamic acid, and glutamine in the fibrous roots.

Source of Variation	D.F.	Nematodes	Tap Roots	Fibrous Roots	Aspartic Acid	Glutamic Acid	Glutamine
Nematodes vs healthy	1	.	1.06	2.89	11.89**	39.66**	16.05**
Error a	18						
Varieties	10	<1.00	4.24**	22.91**	5.73**	2.34**	3.36**
Varieties x nematode eff.	10		1.41	4.00**	<1.00	<1.00	<1.00
Error b	620						
Total	659						

** Significant at $p = .01$.

Significant correlations were also obtained between fibrous and tap root weights and the three amino acids (table 11). Here again the correlations in nematode infected plants were larger than in healthy plants and in many cases significantly larger. This trend held true for most varieties. When comparing varieties, closer relationship between most characters measured were found in the varieties, Acc 107, 28-1, 594-2, and US 33. Three of these varieties were the ones that exhibited the most genetic variation.

Discussion

In those characters effected by nematodes, there appears to be an additional environmental variance introduced by the addition of nematodes. This additional error is probably the combination of error involved in inoculating and the variation of nematode invasion between plants. The significant increase in total genotypic variance in nematode infected plants compared with healthy plants implies they are estimates of different variances and suggests that these two variances are influenced by different groups or parts of different groups of genes. This would result in the development of the following variance equations:

Variance of healthy plants = $V_e + V_{gh}$

Variance of nematode-infected plants = $V_e + V_{en} + V_{gn}$

Where: V_e = environmental variance

V_{en} = additional environmental variance as a result of adding nematodes

V_{gh} = genotypic variance under healthy conditions

V_{gn} = genotypic variance under nematode conditions

The closer relationships in nematode-infected plants compared with healthy plants also suggests different genetic effects on these characters due to nematodes.

A selection scheme based on the concentration of aspartic acid, glutamic acid, and glutamine in the fibrous roots of nematode-infected plants appears to have more promise than counting cysts. However, this test was carried out in the greenhouse and further testing needs to be conducted in the field to determine if the observed effects are related to resistance in the field. Selections have been made for this further testing.

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Table 9. Variances of nematode counts and tap root weights, fibrous root weights, and concentration of aspartic acid, glutamic acid, and glutamine in nematode and healthy conditions.

Variety	Nematodes x 10 ⁺³	Tap roots		Fibrous roots		Aspartic acid		Glutamic acid		Glutamine	
		Nema	Healthy	Nema	Healthy	Nema	Healthy	Nema	Healthy	Nema	Healthy
US 41	6.12	1.127	1.346	1.116*	0.734*	3.33	1.68	8.69	7.99	29.87	15.86
56-408	4.94	0.578	0.697	0.458	0.550	5.83**	2.04	10.67	5.76	35.49	10.91
592-3	5.59	1.036	1.439	0.670*	0.180	1.75	2.61	3.46	5.31	10.36	14.36
Acc 107	5.36	2.504**	2.780**	0.343	0.375	4.21*	3.55*	23.12**	18.87**	78.26**	27.17**
590-1	5.02	1.207	1.032	0.405	0.408	0.79	2.03	20.60	9.87	62.38**	14.34
28-1	7.68	1.303	0.969	1.323**	0.207	3.97	4.53**	25.86**	8.70	83.80**	33.36**
594-2	4.00	1.845**	1.081	0.695*	0.399	6.89**	4.84**	20.47	15.27*	41.32	24.55*
62-9134	7.20	1.005	0.721	0.388	0.261	2.35	1.91	12.86	7.34	24.29	11.03
S 2	5.67	0.786	1.064	0.565	0.496	2.23	2.84	4.18	12.79*	9.72	10.45
C5600	7.98	0.622	0.866	0.332	0.182	2.02	1.53	11.47	5.75	31.75	8.65
US 33	7.91	1.040	0.540	0.576	0.416	5.19*	0.45	12.76	5.32	38.91	6.99
Est. V _e	7.59	0.758	0.794	0.360 ^a	0.222	2.18 ^a	1.72	12.16 ^a	6.54	29.52 ^a	9.84
Est. V _g	-1.13	0.438**	0.507**	0.354** ^a	0.215*	2.96** ^a	0.65*	2.84	2.80*	14.10* ^a	6.40*

* = Significant genotypic variance at p = .05.

** = Significant genotypic variance at p = .01.

^a = Significant increase in total variance in nematode plants over healthy plants at p = .05.

Table 10. Correlations of nematode cyst counts with tap root weights, fibrous root weights, aspartic acid, glutamic acid, and glutamine for the eleven varieties tested.

Variety	Nema x tap root	Nema x fibrous rt.	Nema x aspartic	Nema x glutamic	Nema x glutamine
US 41	-.15	-.20	.25	.29	.25
56-408	.31	.04	-.10	-.20	-.20
592-3	.11	-.02	-.03	-.08	-.25
Acc 107	.04	-.04	.08	.24	.25
590-1	.18	.18	-.22	-.21	-.15
28-1	.16	-.16	-.10	-.03	-.24
594-2	.65**	.62**	-.51*	.40	-.51*
HF1	.44*	.32	-.35	.07	.53*
S 2	.40	.04	-.07	-.11	.19
C5600	.42*	.22	.07	-.19	-.27
US 33	.24	.30	-.16	-.43*	-.37
Total	.23*	.12	-.05	-.14	-.10

* = Significant correlation at $p = .05$.

** = Significant correlation at $p = .01$.

Table 11. Correlations among the three amino acids tested in healthy and nematode infected plants for the eleven varieties.

Varieties	Aspartic x glutamic		Aspartic x glutamine		Glutamic x glutamine	
	Healthy	Nema	Healthy	Nema	Healthy	Nema
US 41	.10	.72**	.37	.75**	.53*	.80**
56-408	.48*	.71**	.78**	.66**	.65**	.80**
592-3	.31	.36	.52*	.38	.70**	.67**
Acc 107	.38	.71**	.22	.77**	.89**	.97**
590-1	.45*	.54*	.33	.61*	.72**	.57*
28-1	.32	.59*	.16	.72**	.44	.83**
594-2	.35	.66**	.40	.55*	.81**	.86**
HFI	-.09	.05	.44	.06	.56*	.74**
S 2	.29	.60*	.27	.42	.60*	.34
C5600	-.41	.62**	.31	.41	.21	.80**
US 33	-.06	.76**	.08	.76**	.74**	.74*
Total	.28**	.57**	.36**	.40**	.63**	.77**

* = Significant correlation at $p = .05$.

** = Significant correlation at $p = .01$.

Table 12. Correlations between tap and fibrous root weights and tap and fibrous root weights with the three amino acids tested in healthy and infected plants for the eleven varieties.

Varieties	Tap x fibrous		Tap x aspartic		Tap x glutamic		Tap x glutamine		Fibrous x aspartic		Fibrous x glutamic		Fibrous x glutamine	
	Healthy	Nema	Healthy	Nema	Healthy	Nema	Healthy	Nema	Healthy	Nema	Healthy	Nema	Healthy	Nema
US 41	.25	.49*	.21	-.37	.26	-.17	-.41	-.22	.01	-.68**	.43	-.57*	.08	-.51*
56-408	.65**	.43	.25	-.31	.02	-.65**	.10	-.58*	-.23	-.62*	-.09	-.53*	-.14	-.50*
592-3	-.02	.60**	.47	-.06	.13	-.01	.31	.05	-.17	-.02	-.53*	-.04	.46	.03
Acc 107	.51*	.78**	.16	-.03	-.14	-.19	-.56*	-.35	-.26	-.15	-.60*	-.27	-.57*	-.44
590-1	.34	.35	-.16	-.50*	.20	-.22	-.09	-.27	-.23	-.54*	-.16	-.13	-.20	-.20
28-1	.47*	.73**	.17	-.62**	.21	-.56*	-.52*	-.60*	-.18	-.74**	-.05	-.49	.35	-.67**
594-2	.27	.40*	.13	-.57*	.16	-.81**	-.03	-.58*	-.18	-.55*	-.21	-.62*	-.51*	-.50*
HFI	.32	.66**	-.05	-.64**	-.41	-.40	-.06	-.19	.14	-.52*	-.41	-.43	-.18	-.13
S 2	.59**	.13	-.25	-.65**	-.02	-.44	-.09	-.58*	.09	-.49	-.33	-.38	-.37	-.35
C5600	.55**	.56**	.19	-.21	-.03	-.32	-.05	-.42	.27	-.45	-.16	-.16	-.01	-.38
US 33	.08	.72**	.02	-.81**	-.30	-.61*	.09	-.60*	.39	-.73**	-.41	.23	-.02	-.58*
Total	.30**	.48**	.17*	-.34**	-.02	-.37**	-.01	-.31**	-.06	-.47**	-.24**	-.45**	-.17*	-.44**

* = Significant correlation at $p = .05$.

** = Significant correlation at $p = .01$.

2. Environmental Factors Affecting Nematode Invasion

In attempting to reduce the environmental variation of nematode invasion, three other studies were initiated to evaluate the influence of certain environmental factors on nematode invasion.

(a) Inoculation Technique.

Various methods of inoculating with nematode larvae were studied. These included: (1) Inoculation around the stem of the plant, (2) Inoculation around the periphery of the soilball, (3) Inoculating in sand flats before transplanting, and others.

There was not a great deal of difference between any of the techniques, however, it appeared as if inoculating around the base of the plant was the best of those techniques tested.

(b) Effect of Soil Moisture of Nematode Invasion.

Three methods of irrigation were studied in connection with nematode population growth and development.

Great differences in yield due to the irrigation system were observed. However, even though these large effects on yield were obtained there was no significant difference in nematode population growth and development due to irrigation system.

(c) Effect of Nitrogen on Nematode Population Growth and Development.

The following treatments were studied as to their effect on nematodes:

1. No nitrogen added
2. Nitrogen in the form of $\text{Ca}(\text{NO}_3)_2$
3. Nitrogen in the form of $(\text{NH}_4)_2\text{SO}_4$
4. Nitrogen in the form of both $\text{Ca}(\text{NO}_3)_2$ and $(\text{NH}_4)_2\text{SO}_4$

Yields were affected by the amount and form of nitrogen added, but nematode population growth and development was unaffected by the above nitrogen treatments.

C. Nematode - Fungi Interactions

In a study conducted in 1966 (Unpublished data) evidence was obtained suggesting an interaction of sugarbeet nematode and Rhizoctonia. Breeding for rhizoctonia resistance has been carried on for some time, however, it was desirable to see if progress could be achieved by selecting for resistance to the nematode-rhizoctonia interaction, and how this interaction is affected by selection in either direction. The following study was conducted in an attempt to evaluate some of the better nematode selections in terms of this nematode-fungi interaction.

Three nematode tolerant selections, their parents, a highly heterozygous variety, and a uniform hybrid were planted in aluminum cylinders in a dark well-aerated soil December 15, 1966. Six plants of each variety were randomized in each flat. Sixteen flats were planted. Using flats as whole plots, the following treatments were applied in a split-plot design:

1. Clean soil
2. Soil inoculated with nematode larvae
3. Soil inoculated with rhizoctonia
4. Soil inoculated with nematode larvae and rhizoctonia.

Flats were separated from each other and a board removed between adjoining flat to prevent the spread of rhizoctonia.

The nematodes (3,000 per plant) were added December 23, 1966 and the rhizoctonia added January 5, 1967. Plants were harvested March 23, 1967.

Results

Plants were not fertilized during this test and toward the end of the test plants in flats in which nematodes had been added were much lighter in color than plants without nematodes. Plants with nematodes and rhizoctonia were a little darker in color than plants with nematodes only.

The yields of the eight varieties for the four treatments are shown in table 13. There was no rhizoctonia effect on any of the varieties, in fact, there was a slight increase in yield when rhizoctonia was added. The nematodes caused a significant reduction in yield but there was no nematode-rhizoctonia interaction. The varieties that yielded highest in clean soil also yielded highest in nematode soil. The selections yielded higher than their parents in almost every case.

Apparently the conditions of this test, such as environmental conditions, time, and amount of inoculations, etc., were such that the interaction observed in earlier experiments was not present.

Table 13. Mean yields of varieties for clean soil, nematode soil, soil inoculated with Rhizoctonia and soil inoculated with nematode larvae and Rhizoctonia.

Varieties	Clean	Nematode	Rhizoctonia	Nema + Rhizoctonia
590-9	13.6	4.1	14.9	7.9
S 2	5.4	4.9	8.3	3.6
592-1	10.9	5.3	12.9	6.3
US 33	6.3	2.7	7.9	7.3
590-1	7.8	3.4	11.1	4.7
Acc 107	13.8	9.1	16.9	7.0
US 41	10.3	4.0	10.6	5.1
F58-554H1	11.0	7.3	9.1	4.6
Total	9.92a*	5.13b	11.62a	5.94b

* Means followed by the same letter are not significantly different at $p = .05$.

RUBBER ROOT AND WILT OF SUGARBEET

E. G. Ruppel and H. W. Reynolds^{1/}

In the spring of 1965 and again in 1966 a wilt disease of mature sugarbeets was observed in experimental plots in the Salt River Valley (Maricopa County) of Arizona. Incidence of the disease was estimated at less than one percent in any field. The disease recurred in the first commercial sugar crop in 1967 and was estimated at five percent or more in all the fields that were inspected.

SYMPTOMS

The primary symptom of the disease usually was evident in March when the beets were about six months old. Affected plants, scattered throughout the field, wilted during the warm sunny days but tended to recover somewhat at night and after irrigation. No leaf or root lesions were evident and no vascular discoloration was detected at this time; however, the terminal portion of the tap root of affected plants was rather flaccid and rubbery. As the day and night temperatures increased, more wilted plants were observed and recovery was slower or nil during cool or wet periods. Also, the oldest leaves of the crown developed large irregular necrotic areas in the lamina and along the petioles. Eventually, in June, almost all the leaves of affected plants were necrotic except for a few of the youngest heart leaves (Fig. 1). Again, carefully dug tap roots of such plants did not exhibit any necrosis, vascular discoloration, or rot. But it was noticed that secondary roots and the hair-like lateral roots along the main tap root were either absent or dry and necrotic (Fig. 2). The tap roots were slightly shriveled and rubbery, whereas healthy roots were turgid. Diseased roots tended to regain their turgidity when they were topped and placed in water.

ISOLATIONS AND INOCULATIONS

Isolations were made from wilted tap roots and necrotic leaves of diseased plants growing in experimental plots in 1966. Rhizoctonia solani Kuehn and R. bataticola (Taub.) Butl. (= Macrophomina phaseoli [Maubl.] Ashby) were consistently recovered from affected plants and grown in pure culture. The pathogenicity of these isolates, and an isolate of Pythium aphanidermatum (Edson) Fitzp. from the soil of a seed-beet field, was tested in replicated experiments in which:

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(i) sugarbeet seeds were planted in soil mixed with fungus inoculum, (ii) 6-week-old sugarbeet plants were inoculated through a wound made in the taproot; and (iii) inocula were introduced in close proximity to the roots of 6-week-old sugarbeets without wounding. Under conditions of these tests none of the isolates were pathogenic to seedlings or young sugarbeet plants. It is believed that the necrotic aspects of the disease are secondary manifestations induced by nonpathogenic or weakly pathogenic fungi that invade the wilted, prematurely senescent tissues of affected sugarbeets.

NEMATODE INVESTIGATIONS

The nature of the wilt disease and the failure to isolate pathogenic microorganisms directed attention to the possibility of a nematode association with the disease. Soil samples collected from the root zones of diseased beets were assayed for nematodes. The assays revealed root-lesion nematodes (Pratylenchus brachyurus [Godfrey] Filipjev & Stekhoven) and a large population of the stunt nematode (Tylenchorhynchus cylindricus Cobb). Further, in separate greenhouse tests by Reynolds and myself, we have obtained great increases in the populations of both species on sugarbeet seedlings. Work has begun to determine the role of these ectoparasitic nematodes in the rubber root and wilt disease of sugarbeets in Arizona.



Fig. 1.--Advanced symptoms of rubber root and wilt of a 6-month-old sugarbeet; note shriveled, flaccid taproot, the lack of healthy lateral roots, and the older necrotic leaves of the crown.



Fig. 2.--Sugarbeet taproots showing various degrees of disease. When the beets were dug: A) 90% of crown leaves were necrotic; B) 10% of crown leaves were necrotic; C) most crown leaves were healthy.

P A R T III

Progress reports of research conducted at
Crops Research Laboratory, Utah State University, Logan, Utah
by the
Staff of Sugarbeet Investigations, ARS-USDA
in cooperation with:

Utah Agricultural Experiment Station
and
Beet Sugar Development Foundation,
Fort Collins, Colorado

Research was conducted by:

G. K. Ryser J. C. Theurer
Myron Stout

Variety Tests, Logan, Utah, 1967

George K. Ryser, J. C. Theurer, and Myron Stout

SOIL TYPES: Silty loam on North Farm and sandy loam on Farmington Farm.

PREVIOUS CROPS: 1966 Safflower at the North Farm and 1966 tomatoes at Farmington Farm.

FERTILIZER: All fields received approximately 400 pounds per acre of 24-20-0 harrowed in before planting.

PLANTING DATES: North Farm, May 9, 1967. Due to heavy rains, crusting, and poor stands, this planting was discarded. Replanted June 2, 1967. Farmington Farm, April 28, 1967.

THINNING DATES: North Farm, June 28 and 30, 1967. Farmington, May 29, 1967.

IRRIGATIONS: North Farm sprinkled after replanting, before and after thinning and on a weekly schedule until two weeks prior to harvest. Farmington furrow irrigated on a weekly basis after thinning until two weeks prior to harvest.

Tops were removed with a rotobeaer and scalped with tractor-mounted scalping tools supplemented by long-handled hoe trimming to assure a complete topping job. Beets in plots were counted when put into weighing basket on harvester. A ten-beet sample was taken at random from harvester table, from each row of the two-row plots for sugar analysis and all beets in plot weighed to determine root yield.

EXPERIMENTAL DESIGN: Test 1 consisted of 32 varieties planted at the North Farm in randomized blocks with eight replications. The varieties consisted of 28 of the best performing hybrids over the last four years where seed was available for retesting. US 22/3, 1114, A607 (Amalgamated Commercial), A602 (U-1 Commercial) and A7126 (U-1 single cross) were used as checks.

Test 2 was planted in randomized block split-plot design with 12 whole plots (females) and two paired sub-plots of equivalent restorer and non-restorer males, replicated eight times at each of the two locations. (Test 2 is titled "Comparative performance of pollen restorer and non-restorer hybrids from the same inbred lines of sugarbeets Beta vulgaris L." and follows Test 5 in this report.)

Test 3 was planted at Logan in a randomized block experiment and included nine new hybrid combinations with three checks in eight replications.

Test 4 and 5 were planted also in randomized blocks. Test 4 consisted of 24 entries in six replications; two parent varieties 030 and 0461 together with individual beet selections from these lines for high sugar, high index and low impurity. Test 5 with four replications included parents 030, 0461 and four sugar selections where seed was harvested from aa plants.

Test 1

This test was a re-evaluation of the hybrids that had shown promise in the last four years' variety tests.

The single cross 51157 (EL 33 X 9540 sugar selection) was highest in gross sugar but not significantly above the next three varieties 41271, 31980, and 31998-1 (Table 1). It was significantly better than all five checks. The best four-way or double-cross hybrid (5159) was eighth in gross sugar.

The two single crosses, 51157 and 41271, were highest on tons of beets per acre.

Variety 31980, having L-19 as a male parent and 51114 and 51112 with 0198 sugar selection as pollinator were highest in sucrose percent (Table 1). Line 51114 was significantly better than any other variety in the test except 31980 for this factor.

With the exception of two other varieties, 51157 had the poorest quality as noted by the high impurity index value of 579 (Table 1A.) Hybrid 5196, a double-cross restorer hybrid had the lowest impurity index but was not significantly superior to seven of the other hybrids in the test.

Further comparisons for the eight variables for any entry in the test can be observed by noting the Duncan's least significant ranges indicated by letters following the hybrid means.

Test 3

Nine new hybrid combinations produced in isolation seed plots in 1966, were compared with check varieties to evaluate their merit as potential breeding material.

Variety 6132 was significantly better than seven of the varieties, which included all of the checks except the U-1 Commercial, A604. Five crosses with the female 308 showed the specific combining ability with different male parents. The entries ranked similarly for tonnage as they did for gross sugar.

Table 1. Test 1, North Farm, Logan, Utah, 1967.

Variety No.	Description	Acre yield		Percent sugar	Beet count
		Gross sugar	Tons beets		
51157	EL33 X 5940Sug. Sel.	4593 a*	18.27 a	13.58 bcdef	56
41271	AI-1 X CT9B	4665 ab	17.17 ab	13.59 bcdef	58
31980	(9132XCT5)XL-19	4519 abc	15.86 bcde	14.24 ab	48
31998-1	NB-1 X 630S2	4415 abcd	15.92 bcd	13.85 bcd	47
31940-1	(133XCT5A)X630S2	4384 bcde	16.16 bcd	13.56 bcdef	59
51114	AI-10X0198Sug. Sel.	4352 bcdef	15.22 bcdefg	15.64 a	46
A604	U-1 Commercial	4321 bcdefg	16.14 bcd	13.37 bcdefg	61
A7126	U-1 Single Cross	4263 bcdefgh	15.48 bcde	13.74 bcde	63
5159	(308Xm')X(AI-1R _f)	4180 bcdefghi	15.68 bcde	13.27 bcdefghi	59
51162	AI-1X0198Sug. Sel.	4179 bcdefghi	16.16 bcd	12.94 defghi	56
51112	0156X0198 Sug. Sel	4049 cdefghij	14.41 cdefg	14.01 bc	32
1101	0157 X 0457	4047 cdefghij	15.84 bcde	12.77 efghi	54
5140	(AI-1XE131)X(129R _f)	4044 cdefghij	15.00 bcdefg	13.47 bcdef	56
51136	129 X 712 Sug.	4042 cdefghij	15.30 bcdef	13.16 cdefghi	53
5160-	(308XCT5B)X(AI-1R _f)	4040 cdefghij	16.30 bc	12.39 ghi	54
51172	(129X0v1)X(FC503R _f)	4010 cdefghijk	15.04 bcdefg	13.33 bcdefg	54
1104	0168 X 0457	3951 cdefghijk	14.61 cdefg	13.53 bcdef	46
51260	(308XE131)X(129R _f)	3936 cdefghijk	15.52 bcde	12.66 fghi	56
US 22/3	US 22/3	3910 cdefghijk	14.23 cdefg	13.72 bcde	54
A607	Amalg. Commercial	3858 defghijk	14.17 cdefg	13.60 bcdef	48
51201	(CT9XE132)X(129R _f)	3823 defghijk	14.65 cdefg	13.05 cdefghi	53
51137	128 X 712 Sug.	3815 defghijk	14.67 cdefg	12.96 defghi	48
1114	1114	3777 efghijk	14.51 cdefg	13.04 cdefghi	52
5196	(129XCT5B)X(C515R _f)	3764 fghijk	14.01 defg	13.41 bcdef	54
51139	AI-1 X 712 Sug.	3694 ghijk	15.05 bcdefg	12.31 hi	56
0156	9142 X 924	3609 hijk	13.63 cfg	13.23 cdefghi	50
5152	(503XCT5)X(AI-1R _f)	3604 ijk	13.65 efg	13.18 cdefghi	46
2162	0156 X 0548	3565 ijk	13.99 defg	12.69 fghi	50
5155	(128XE131)X(AI-1R _f)	3521 ji	13.18 fg	13.33 bcdefg	52
5164	(129X032)X(C515R _f)	3521 jk	13.22 fg	13.27 bcdefgh	50
2158	1120X(711 X 713)	3452 jk	12.70 g	13.56 bcdef	51
51194	(308X00.5)X(129R _f)	3384 jk	14.19 cdefg	11.90 i	52
Gen. Mean All Varieties		3989	15.00	13.32	52
S. E. of Mean		178.1	.64	.29	2.9
S. E. Diff.		499.2	1.80	.80	8.1
Coefficient of Variation %		17.7	16.64	7.57	20
Calculated F		4.3	3.49	5.19	3.9

* Duncan's new multiple range test means having same letter are not significantly different (5% level).

Table 1A. Test 1, North Farm, Logan, Utah, 1967.

Variety No.	Description	Impurity index	PPM			
			Amino N	Na	K	
51157	EL33 X 5940Sug.Sel.	677 klm	361 ghijkl	579 mn	1409	kl
41271	AI-1 X CT9B	519 bcdefgh	326 defghi	394 defghij	959	abcd
31980	(9132XCT5) X L-19	499 abcdefg	267 abcd	370 cdefgh	1261	ijk
31998-1	NB-1 X 630S2	593 hijk	397 ijklm	317 abcd	1227	hij
31940-1	(133 X CT5A)X630S2	551 defghi	346 fghijkl	373 cdefgh	1076	bcdefghi
51114	AI-10X0198 Sug.Sel.	576 efghi	439 m	216 a	1260	ijk
A604	U-1 Commercial	560 defghi	345 fghijk	404 defghij	1048	abcdefgh
A7126	U-1 Single Cross	522 bcdefgh	392 hijklm	295 abc	884	a
5159	(308Xm')X(AI-1R _f)	668 jklm	399 jklm	516 klm	1208	ghij
51162	AI-1 X 0198 Sug.Sel.	560 defghi	279 bcdef	466 ijkl	1118	cdefghij
51112	0156X0198 Sug. Sel.	436 ab	230 ab	278 ab	1138	defghij
1101	0157 X 0457	612 hijk	365 ghijkl	451 ghijkl	1018	abcdefg
5140	(AI-1XEL31)X(129R _f)	555 defghi	341 efghijk	423 efghij	1029	abcdefg
51136	129 X 712 Sug.	536 defgh	281 bcdef	429 efghijk	1089	cdefghij
5160-	(308XCT5B)X(AI-1R _f)	706 lm	418 lm	462 ijkl	1156	efghij
51172	(129X0v1)X(FC503R _f)	548 defghi	324 defgh	386 defghi	1073	abcdefghi
1104	0168 X 0457	586 feghij	409 klm	346 abcdef	1041	abcdefgh
51260	(308XEL31)X(129R _f)	634 ijkl	327 defghij	525 lm	1165	fghij
US 22/3	US 22/3	613 ijk	392 hijklm	373 cdefgh	1270	jkl
A607	Amalg. Commercial	613 hijk	422 lm	322 abcd	1190	fghij
51201	(CT9XEL32)X(129R _f)	539 defghi	271 abcde	448 ghijkl	1091	cdefghij
51137	128 X 712 Sug.	546 defghi	300 bcdefg	407 defghij	1059	abcdefgh
1114	1114	500 abcdefg	286 bcdef	362 bcdefg	946	abc
5196	(129XCT5B)X(C515R _f)	418 a	403 a	329 abcd	970	abcde
51139	AI-1 X 712 Sug.	569 efghi	247 ab	484 jkl	1116	cdefghij
0156	9142 X 924	440 abc	242 ab	328 abcd	898	ab
5152	(503XCT5)X(AI-1R _f)	490 abcde	248 abc	389 defghi	1033	abcdefg
2162	0156 X 0548	530 cdefgh	283 bcdef	440 ghijkl	931	abc
5155	(129XEL31)X(AI-1R _f)	496 abcdef	296 bcdefg	348 abcdef	972	abcde
5164	(129X032)X(C515R _f)	563 efghi	317 cdefg	437 fghijkl	1107	cdefghij
2158	1120X(711 X 713)	471 abcd	268 abcde	342 abcde	1011	abcdef
51194	(308X00.5)X(129R _f)	739 m	298 bcdefg	625 n	1432	l
Gen. Mean All Varieties		558	322	402	1099	
S. E. of Mean		27.9	21.6	27.4	55.7	
S. E. Diff.		78.2	60.7	76.3	155.8	
Coefficient of Var. %		19.9	27.3	30.4	21.6	
Calculated F		7.2	8.5	10.1	5.8	

The single cross, 6175, led all others in percent sugar, but was only significantly better than five other entries. Of interest was the observation that pollinators derived from Ovana material (Ov 1 and Ov 2) were the male parents of the three varieties, which were highest in this characteristic (Table 3).

The C515 X Ov 2 cross exhibited the best quality while C515 X 0198 had the highest impurity index value. Lines 6129, 6132, 6137, and 6139 were significantly higher in impurities than the other varieties in the test.

Test 4

This test was designed to measure the value of two cycles of individual beet selections in two inbred lines, 030, and 0461. Selections for high sugar percentage, high index, and low index were seeded in a randomized block planting with parental varieties.

In 1965, there were two or three levels in each selection group based upon the number of beets that could be conveniently handled in our seed isolation chambers. For example, in the 030 high sugar selection, three isolation chambers were used to produce the seed. Selected beets were planted in highest, intermediate and lowest one-third groups in the respective chambers.

Since the parental lines are self fertile, open pollination within groups resulted primarily in selfing, which gave an expected decrease in tonnage and gross sugar for the selections (Tables 4A, 4B).

The high index selections had the lowest sugar percent in both groups. In the 030 population, the high sugar selection, 6700-09-1 was significantly better in sugar percent than the parent or the intermediate sister line 6700-09-2, but was not better than 5700-1, the first cycle selection (Table 4A).

High index selections were significantly different from the parent in impurity index values for both cycles.

There was no significance in the 0461 population, comparing selections to parents except for high index (Table 4B).

Averages of the selected beets and the resulting population performance are shown in Table 4C in percent of the 030 parent. The first grouping under each of the three sections refers to the first cycle selected in 1964, and the other three groups to 1965 selections. In most instances, there was a decrease in the performance of the population when compared to the selected beets from which the population was derived. The second cycle of selection showed a decrease in yield and sugar and an increase in the index and component impurity factors for the high sugar and low impurity groups. The only evidence of significant progress made by selection was for high impurity indices.

Table 3. Test 3, North Farm, Logan, Utah, 1967.

Var. no.	Description	Acre yield		Percent sugar	Impurity index	PPM			Beet count
		Gross sugar	Tons beets			Amino N	Na	K	
6132	308 X 0198	4997 a*	18.87 a	13.19 abcd	793 e	477 cde	670 e	1291 d	52
6180	308 X 0v 1	4405 ab	16.16 ab	13.63 a	621 ab	440 cd	306 a	1195 cd	55
6139	308 X L-13	4391 ab	17.01 ab	12.91 cd	732 de	452 cde	586 de	1146 bc	33
A604	U-1 Commercial	4308 ab	15.96 b	13.49 ab	572 ab	360 ab	435 c	1024 ab	59
6137	308 X NB-1	4292 ab	16.70 ab	12.84 d	792 e	501 de	530 d	1316 d	29
1101	1101	4198 b	16.36 ab	12.83 d	635 abc	415 abc	444 c	968 a	56
6129	0515 X 0198	4168 b	16.20 ab	12.86 d	804 e	528 e	631 e	1119 bc	55
6175	0515 X 0v 2	4160 b	15.16 b	13.71 a	506 a	331 a	394 bc	899 a	58
6105	133 X 0v 1	4148 b	15.13 b	13.68 a	617 ab	456 cde	377 abc	1023 ab	47
6118	308 X A1-10	4056 b	15.58 b	12.99 bcd	709 cd	469 cde	445 c	1183 cd	49
A607	Ang. Commercial	3938 b	14.61 b	13.44 abc	610 ab	429 bcd	312 ab	1126 bc	51
6302	0461 X A1-10	3761 b	14.10 b	13.36 abcd	651 bc	510 de	302 a	1010 ab	45
Gen. Mean All Var.		4235	15.99	13.24	670	447	453	1108	49
S. E. of Mean		248.1	.88	.18	25.4	24.8	28.9	45.5	1.9
Sig. Diff.		NS	2.46	.51	71.1	69.5	81.0	127.3	5.4
Coef. of Variation %		16.9	16.26	4.61	17.2	19.8	33.3	16.5	21.6
Calculated F		1.5	2.01	3.65	14.2	5.5	19.2	7.9	24.9

* Duncan's new multiple range test. Means having same letter are not significantly different (5% level).

Table 4A. Individual beet selection O30 test 4, North Farm, Logan, Utah , 1967 .

Code	Description	Acre yield		Percent sugar	Index	PPM			Beet count
		Gross sugar	Tons beets			Amino N	Na	K	
12	O30 Parent	4305	15.71	13.68	576	364	373	1163	56
20	High Index 5700-3	4216	15.65	13.49	678	455	398	1260	54
17	High Index 6700-10-4	4197	16.13	12.99	766	474	462	1426	62
16	High Sugar 5700-1	3955	13.72	14.38	573	418	316	1181	48
18	High Index 6700-10-5	3876	14.83	13.08	837	598	434	1366	62
13	High Sugar 6700-09-1	3581	12.37	14.46	510	377	230	1119	47
15	High Sugar 6700-09-3	3431	12.20	14.05	484	307	292	1082	48
19	High Index 6700-10-6	3306	12.68	13.06	743	464	400	1449	49
24	Low Index 5700-5	3263	11.89	13.73	543	328	379	1138	43
14	High Sugar 6700-09-2	2958	10.88	13.62	570	393	312	1084	50
21	Low Index 6700-11-7	2848	10.22	13.91	532	374	329	1000	48
23	Low Index 6700-11-9	2789	10.11	13.79	539	378	321	1007	41
22	Low Index 6700-11-8	2472	9.00	13.71	433	245	295	973	39
Gen. Mean All Varieties		3477	12.72	13.69	599	398	349	1173	50
S. E. of Mean		164.7	.61	.16	32.2	34.6	21.9	45.9	3.0
S. E. Diff.		465.8	1.72	.45	91.0	97.9	61.9	129.9	8.4
Coef. of Variation in %		21.0	21.91	4.14	23.3	29.5	22.7	16.8	20.7
Calculated F		13.4	14.86	8.33	14.0	6.5	8.8	12.0	5.8

Table 4B. Individual beet selection 0461, test 4, North Farm, Logan, Utah, 1967.

Code	Description	Acre yield		Percent sugar	Index	PPM			Beet count
		Gross sugar	Tons beets			Amino N	Na	K	
01	0461 Parent	3502	12.92	13.53	666	549	232	1063	62
11	Low Index 5701-4	3227	12.02	13.44	683	549	297	1053	47
07	High Index 6701-13-11	3190	12.34	12.97	807	569	420	1310	50
05	High Sugar 5701-1	3072	11.40	13.48	645	504	254	1089	50
06	High Index 6701-13-10	3050	12.23	12.44	1044	794	479	1320	53
09	Low Index 6701-14-15	2869	10.32	13.88	516	374	253	1014	47
08	High Index 5701-2	2750	10.53	13.06	868	721	316	1166	48
10	Low Index 6701-14-16	2696	9.93	13.54	629	486	240	1127	43
03	High Sugar 6701-12-13	2539	9.60	13.14	662	529	222	1048	47
02	High Sugar 6701-12-12	2513	9.29	13.48	615	473	266	1052	43
04	High Sugar 6701-12-14	2458	9.05	13.56	617	461	266	1123	43
Gen. Mean All Varieties		2899	10.88	13.32	705	546	295	1124	48
S. E. of Mean		186.2	.66	.56	41.7	45.2	26.0	39.3	2.8
S. E. Diff.		529.1	1.89	1.60	118.5	128.3	73.6	111.7	7.9
Coef. of Variation in %		19.0	19.18	4.11	24.2	28.2	33.6	12.1	18.5
Calculated F		3.3	4.20	4.81	12.5	6.9	9.9	7.0	4.0

Table 4C. Results of individual beet selection with selfed generations of 030. In percent of parent 030.

Average	Wt.	Sugar	Index	N	Na	K
		<u>HIGH SUGAR</u>	<u>SELECTION</u>	<u>BASIS</u>		
Sel. beets	121.0	109.0	77.2	93.3	57.0	81.0
Population	93.6	104.6	93.0	114.5	90.1	92.6
Sel. beets - 1	114.5	123.7	45.7	56.6	25.4	75.8
Population	78.7	105.7	88.5	103.6	61.7	96.2
Sel. beets - 2	116.0	116.1	72.9	110.0	46.2	95.5
Population	69.3	99.6	99.0	102.5	83.6	93.2
Sel. beets - 3	114.4	112.1	70.4	91.7	60.6	86.6
Population	77.7	102.7	84.0	84.3	78.2	93.0
		<u>HIGH</u>	<u>INDEX</u>	<u>BASIS</u>		
Sel. beets	132.7	92.3	197.6	209.4	290.4	166.6
Population	100.2	95.7	134.6	141.3	134.8	122.0
Sel. beets - 1	130.0	76.7	246.7	223.6	239.8	145.9
Population	102.6	95.0	134.9	130.2	123.9	122.9
Sel. beets - 2	110.6	86.9	188.6	181.4	205.4	149.3
Population	94.4	95.6	145.3	164.3	116.4	117.4
Sel. beets - 3	123.8	94.1	162.3	172.0	162.6	148.0
Population	80.7	95.5	129.0	127.5	107.2	124.6
		<u>LOW</u>	<u>INDEX</u>	<u>BASIS</u>		
Sel. beets	87.2	104.0	65.8	72.9	42.1	71.5
Population	90.9	102.3	102.6	123.3	99.8	96.6
Sel. beets - 1	102.5	110.3	63.5	91.1	84.9	55.4
Population	65.0	101.7	92.4	102.7	88.2	86.0
Sel. beets - 2	122.6	112.6	47.6	66.7	40.7	66.6
Population	57.3	100.2	75.2	67.3	79.1	83.7
Sel. beets - 3	87.6	112.2	41.0	49.0	29.1	56.5
Population	64.4	100.8	93.6	103.8	86.1	86.6

Test 5

This is a preliminary test on progress made in selecting for high sugar and low index utilizing seed from aa plants. The 0461 population is compared with only a low impurity selection (Table 5).

Two entries, high sugar 1 and low impurity index had higher gross sugar than the parent, 030, however, neither value was significant. There was a significant decrease in tons per acre for high sugar 1. The 030 parental line was significantly lowest in percent sugar. The low index selections for both populations consistently had a lower impurity, amino N, Na and K value except in the case of Na for the low index 0461 population.

The 0461 population and its low index selection were not significantly different for any of the factors studied.

Table 5. Individual beet selection, Test 5, North Farm, Logan, Utah, 1967.

Code	Description	Acre yield		Percent sugar	Index	PPM			Beet count
		Gross sugar	Tons beets			Amino N	Na	K	
05	High sugar 2	4436	15.56	14.25	577	452	245	1140	66
06	Low index	4227	14.65	14.41	485	315	285	1129	55
03	030 Parent	4209	15.60	13.51	661	461	314	1272	52
04	High sugar 1	4058	13.81	14.68	572	489	189	1131	60
02	Low index (0461)	3241	12.02	13.46	685	531	266	1151	53
01	0461 Parent	3193	11.62	13.73	704	602	208	1166	48
Gen. Mean All Var.		3894	13.88	14.01	614	475	251	1165	56
S. E. of Mean		123.0	1.88	0.21	34.7	19.1	26.9	NS	2.9
Sig. Diff.		372.3	5.69	0.62	105.2	84.0	81.3	NS	8.9
Coef. of Var. %		14.5	13.33	4.56	16.0	21.5	27.8	9.53	13.9
Calculated F		19.1	12.66	6.10	5.9	10.8	3.8	NS	4.5

Comparative Performance of Pollen Restorer and Non-restorer Hybrids
From the Same Inbred Lines of Sugarbeets, Beta vulgaris L.

J. C. Theurer, G. K. Ryser, and Myron Stout

Two types of male sterility are presently being used in the production of commercial varieties of sugarbeets; a cytoplasmic-genic type discovered by F. V. Owen in 1931, and a genic inherited type observed a few years later (4). Cytoplasmic male sterility (CMS) is of most importance to the sugarbeet industry because it provides a means of controlling pollination and obtaining hybrid seed on a large scale. By contrast, the genic type (a_1) is inherited as a simple Mendelian recessive (5) and is mainly of interest to the breeder in the intermediate steps of a breeding program. Transferring disease resistance, monogerm fruits, or other desirable traits from one pollinator line to another is readily accomplished by this means.

One major sugarbeet company in the continental United States is utilizing both types of sterility in the production of commercial four-way or double-cross hybrid seed in accord with the scheme proposed by Owen (6). The greatest difficulty with this method is the necessary roguing required during the bud stage to eliminate pollen producing plants from the genic male-sterile line which is to be used as the paternal single-cross parent. This requires removal by hand of 50% or more of the plant population of this line since a_1 at maximum segregates one male-sterile: one fertile plant. Recently, we (10) have found a pollen-restorer line in sugarbeets and have demonstrated the feasibility of producing commercial four-way hybrids utilizing only cytoplasmic male sterility. This is accomplished by the cross of (CMS X Type-0 pollinator) X (CMS X R_f pollinator).

Several comparisons have been made of the effects that male-sterile genes and pollen-restorer genes have on agronomic characters of corn inbreds and hybrids. However, only a few of these studies compare the performance of (CMS X restorer) versus (CMS X non-restorer) hybrids.

Noble and Russell (3) observed that single crosses of CMS X R_f lines of corn gave mean grain yields less than equivalent non-CMS crosses, but only one line had a great enough difference to be judged significant. They also cited unpublished results by Duvick who observed an approximate 4% disadvantage for restored-sterile cytoplasm plants compared to normal fertile plants among three-way crosses. The latter also observed an interaction of genotypes with restored-sterile cytoplasm plants indicating that this difference is not consistent. Russell and Marquez-Sanchez (7) found that, in general, yield is not affected in single-cross hybrid corn when both Texas type CMS and R_f genes are present. They did observe significant effects in certain genotypes. In a split-plot experiment with types of cytoplasm being the subplots,

two single-cross hybrids of CMS X R_f yielded lower than normal X R_f counterparts, however, not significantly so (2).

Stringfield (9) reported that normal-fertile and restored-fertile corn are different in the relative yields of grain. He suggests that breeders have been thinking too much about the cytoplasm as a sterilizing mechanism rather than an interacting partner with the nucleus.

Grogan and Sarvella (1) found that morphological differences between normal and restorer versions of corn are quite unpredictable. This they attributed to either linkages with R_f factors, a restorer-sterile cytoplasm reaction, intra-line variation or environment.

The present study was designed to compare the yield and quality performance of CMS X pollen restorer and equivalent non-restorer double-cross hybrids of the same lines of sugarbeets.

MATERIALS AND METHODS

Twelve (CMS X Type-0) single-cross hybrids (Table 3, column 1) were utilized as females and were crossed with F_1 hybrids of (SLC 129 aa X US 201 R_f) and (SLC 129 CMS X US 201 R_f) in separate isolated field seed plots. The 24 double-cross hybrids were planted in split-plot randomized block experiments at Logan, Utah, and at Farmington, Utah, during 1966 and 1967. The subplot (males) was two rows wide, the whole plot four, planted in 22-inch rows 35 feet long.

Seedlings were thinned so as to have beets 10-12 inches apart down the row. The plots were irrigated and cultivated at weekly intervals during the growing season.

At harvest, a ten-beet sample was taken from each row of each plot for sugar and impurity analysis. The entire plot was weighed for root yield. Percent sugar was determined by use of a saccharimeter, amino N, Na and K, by use of spectrophotometers, and gross sugar, tons per acre and an impurity index were calculated in accord with methods published elsewhere (8).

RESULTS AND DISCUSSION

Excellent germination was observed for all entries in each test plot and very little difference was observed in seedling vigor. Differences in foliar characteristics were evident for whole plots, but the paired subplot phenotypes were similar.

Analyses of variance are given in the lower portion of Tables 2 through 2E for the eight characters that were measured.

Means and analyses of variance are given in Tables 2 and 2A for the test grown at the North Farm. Highly significant F values were noted for all variables for both females and males. Lines having EL 31 and Ovana as pollinators had the highest gross sugar while the line 289 parent contributed to low production. The single crosses 308 X EL 31 and 308 X CT 5B had the highest tonnage and were significantly better in yield than the ten other varieties.

SLC 129 X CT 5A was significantly better in quality as shown by the impurity index value of 457. All three components, i.e., amino N, Na, and K were below the means of the test for this variety (Table 2A).

On the average, there was little difference between the restorer versus non-restorer pollinators. The Mendelian male-sterile pollinator averaged greater gross sugar, higher tons per acre, higher percent sucrose and with the exception of Na, was poorer in quality. Considerable female X male interaction was noted for each variable.

A summary of the results of the Farmington test shows that females were highly significantly different for all eight variables (Tables 2B, 2C). Male significance, however, was noted only for tons per acre, sucrose percent, amino N, Na and K (bottom of Tables 2B, 2C). Lines with Ovana (308, Ov. 3) and EL 31 parents again gave greater gross sugar, while crosses with line 289 tended to be among the poorest lines in the test for this factor. Varieties 308 X CT 5A, 308 X CT 5B, and 308 X EL 31, were highest in tonnage. The 308 X CT 5A combination significantly exceeded all but one variety for this variable. Crosses with line 289 showed the greatest percent sucrose, however, six single crosses were not significantly different from the highest variety. The variety with the highest sucrose percentage (308 X Line 289) also had the lowest impurity index in the Farmington test (Table 2B).

Crosses with the CMS X R_f pollinator tended to show greater gross sugar production, more tons per acre, and less sucrose percent than aa-R_f crosses. The pollinators were equal for impurity index values. The aa hybrids had greater amino N, and K, and less Na content than did their CMS counterparts. Male X female interactions were again noted, however, indicating that certain combinations did better in restorer crosses and others vice versa.

Analysis of variance for the combined locations shows significant mean squares for the locations for gross sugar, tons per acre, amino N, K, and beet count (Tables 2D, 2E). The production at Farmington was about twice than observed at Logan (Tables 2, 2B). This no doubt was primarily due to the late spring and the short growing season at Logan. The varieties at Logan averaged 14.83 tons per acre compared to the 31.77 tons per acre at Farmington. Logan plots were considerably higher in amino N and lower in K

than the same varieties at the other location (Tables 2A and 2C). Gross sugar, tonnage, sucrose percent and impurity index had significance for female X location and male X location interactions. The most interesting comparisons are those for male parents. The CMS-R_f hybrids were greater in yield, lower in sucrose, and equal in impurity index values when compared to the average aa-R_f hybrid means (Table 2D). The restorer hybrids were lower in ppm amino N, and ppm K, while non-restorer crosses averaged less Na content (Table 2E).

Highly significant male X female interactions indicated differences in combining ability. Such results stress the importance of testing inbreds for combining ability in the combinations which will be used in a cross. An indication of good combining ability between lines crossed by utilizing the Mendelian male-sterile gene may not necessarily indicate how the hybrid will behave when it is made utilizing equivalent cytoplasmic male sterile lines crossed with pollen restorer males.

The data of this study indicate there may be a heterotic effect on yield and quality of sugarbeet hybrids due to the interaction of sterile cytoplasm and R_f genes. Additional research on specific yield and quality relations of male sterile, normal fertile and restored fertile sugarbeets is needed and is planned for future variety tests.

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Table 1. Performance of CMS restorer versus Mendelian restorer hybrids. Test 2, North Farm, Logan, Utah, 1967.

Code	Description	Gross sugar			Tons per acre			Percent sucrose			Index	
		aa	CMS	Mean	aa	CMS	Mean	aa	CMS	Mean	aa	CMS
04	308 X E1 31	4575	4187	4381	17.15	16.04	16.60	13.33	13.06	13.19	693	659
12	AI-1 X Ov 3	4280	4345	4313	15.58	15.54	15.56	13.72	13.94	13.83	674	573
08	AI-1 X E1 31	4374	4022	4198	15.90	14.41	15.15	13.74	13.93	13.83	614	545
11	308 X CT 5B	3999	4348	4173	15.44	17.05	16.25	12.93	12.74	12.83	566	633
09	CT 9 X FC 503	4192	4135	4163	15.42	15.28	15.35	13.58	13.52	13.55	522	527
03	CT 9 X E1 31	4175	4062	4119	15.22	14.61	14.91	13.70	13.91	13.81	563	493
01	AI-1 X C672	4070	4140	4105	14.88	15.46	15.17	13.66	13.33	13.52	590	576
02	129 X CT 5A	4046	3750	3898	14.95	13.79	14.37	13.52	13.58	13.55	467	447
07	FC 502 X 00.5	3897	3694	3795	14.39	14.27	14.33	13.52	12.92	13.22	527	599
06	AI-1 X CT 5B	3570	3696	3633	13.51	13.83	13.67	13.19	13.35	13.27	560	506
05	308 X Line 289	3542	3668	3605	12.99	13.39	13.19	13.61	13.68	13.65	635	605
10	AI-1 X Line 289	3818	3365	3592	14.03	12.74	13.38	13.59	13.18	13.39	599	716
Mean All Females		4045	3951	3998	14.96	14.70	14.83	13.51	13.43	13.47	584	573
Sig. Dif. at 5%												
Males Same Female		243.97			0.82			2.55			50.36	
Females		265.29			0.22			0.07			45.08	
Males		65.20			0.91			0.25			NS	

Source of Var.	DF	Mean square			F			Mean square			F	
		aa	CMS	Mean	aa	CMS	Mean	aa	CMS	Mean	aa	CMS
Rep	7	54.60 X 10 ⁴	3.88**	.6232 X 10	.6232 X 10	3.78**	.5485 X 00	4.52**	11.09 X 10 ³	11.09 X 10 ³	2.73*	
WP = Females	11	12.71 X 10 ⁵	9.03**	.1859 X 10 ²	.1859 X 10 ²	11.27**	.1518 X 10	12.50**	61.69 X 10 ³	61.69 X 10 ³	15.17**	
Error (A)	77	14.08 X 10 ⁴		.1650 X 10	.1650 X 10		.1214 X 00		40.64 X 10 ²	40.64 X 10 ²		
SP = Males	1	42.01 X 10 ⁴	7.06**	.3187 X 10	.3187 X 10	4.69*	.3242 X 00	4.98*	58.24 X 10 ²	58.24 X 10 ²	NS	
WP X SP	11	24.76 X 10 ⁴	4.16**	.3370 X 10	.3370 X 10	4.95**	.2905 X 00	4.46**	17.21 X 10 ³	17.21 X 10 ³		
Error (B)	84	59.54 X 10 ³		.6803 X 00	.6803 X 00		.6515 X 10 ⁻¹		25.37 X 10 ²	25.37 X 10 ²		
Total	191	19.26 X 10 ⁴		.2474 X 10	.2474 X 10		.2036 X 00		77.36 X 10 ²	77.36 X 10 ²		

Table 2A. Performance of CMS restorer versus Mendelian restorer hybrids. Test 2, North Farm, Logan, Utah, 1967.

Code	Description	Amino N PPM		Na PPM		K PPM		Beet count	
		aa	Mean	aa	Mean	aa	Mean	aa	Mean
04	308 X E1 31	484	453	459	484	1107	1033	65	64
12	AI-1 X Ov 3	541	481	337	387	1055	953	54	56
08	AI-1 X E1 31	450	410	362	388	1060	1006	59	60
11	308 X CT 5B	339	344	396	523	1005	1081	55	57
09	CT 9 X FC 503	313	314	341	420	1110	1001	61	61
03	CT 9 X E1 31	370	348	415	358	1025	938	62	62
01	AI-1 X CT 72	395	387	420	408	1055	986	61	64
02	129 X CT 5A	265	261	326	318	1006	957	57	56
07	FC 502 X 00.5	314	318	378	484	1066	1129	58	57
06	AI-1 X CT 5B	369	341	368	374	963	920	57	58
05	308 X Line 289	505	482	304	362	1004	975	57	56
10	AI-1 X Line 289	461	497	327	408	953	1053	56	57
Mean All Females		400	386	369	390	1034	1003	58	59
Sig. Dif. at 5%									
Males Same Female		53.76		54.33		68.28		NS	
Females			14.37		58.41		74.60		5.78
Males		40.34		14.52		18.25		NS	
Source of Var. DF									
Rep	7	Mean square	F	Mean square	F	Mean square	F	Mean square	F
WP = Females	11	12.54 X 10 ³	3.85**	23.39 X 10 ³	3.43**	46.54 X 10 ³	4.27**	39.54 X 10	5.92**
Error (A)	77	96.54 X 10 ³	29.66**	37.63 X 10 ³	5.54**	30.62 X 10 ³	2.75**	13.14 X 10	1.97*
SP = Males	1	32.55 X 10 ²		68.24 X 10 ²		11.13 X 10 ³		66.80 X 10 ¹	
WP X SP	11	38.03 X 10 ³	13.15**	84.93 X 10 ³	28.76**	46.98 X 10 ³	10.07**	39.44 X 10 ¹	NS
Error (B)	84	10.14 X 10 ³	3.51**	11.43 X 10 ³	3.87**	20.56 X 10 ³	4.34**	16.27 X 10 ¹	NS
Total	191	28.91 X 10 ²		29.53 X 10 ²		46.63 X 10 ²		25.55 X 10 ¹	
		93.86 X 10 ²		81.77 X 10 ²		11.46 X 10 ³		61.37 X 10 ¹	

Table 2B. Performance of CMS-restorer versus Mendelian-restorer hybrids. Test 2, Farmington, Utah, 1967.

Code	Description	Gross sugar		Tons per acre		Percent sucrose		Index	
		aa	Mean	aa	Mean	aa	Mean	aa	Mean
03	CT 9 X EI 31	8964	9438	21.96	33.83	13.97	13.91	549	546
01	AI-1 X C672	8776	9540	32.09	34.21	13.61	13.88	577	504
14	308 X CT 5A	9261	8734	38.31	33.47	12.00	12.93	743	703
13	AI-1 X Ov 3	9167	8586	33.55	32.04	13.62	13.28	576	554
08	AI-1 X EI 31	8675	8890	33.03	32.89	13.08	13.41	598	548
12	308 X CT 5B	8418	9124	31.46	35.40	13.35	12.86	555	663
09	AI-1 X FC 505	8588	8914	30.45	32.18	14.02	13.77	519	511
04	308 X EI 31	9147	8250	35.32	33.31	12.89	12.25	683	725
06	AI-1 X CT 5B	8272	8865	29.19	32.44	14.08	13.56	542	544
02	129 X CT 5A	8543	8527	31.34	32.69	13.61	13.03	523	520
05	308 X Line 289	8159	8339	17.90	28.90	14.61	14.43	464	517
10	CT 9 X FC 503	7769	8428	27.84	30.65	13.91	13.74	554	524
11	AI-1 X Line 289	7933	9116	27.94	28.12	14.24	13.96	525	520
07	FC 502 X 00.5	7879	7577	29.89	29.34	13.12	12.78	593	647
Mean All Females		8539	8652	31.43	32.11	13.58	13.41	572	573
Sig. Dif. at 5%									
Males Same Female		670.80		2.14		0.51		57.78	
Females			792.28		1.91		0.82		86.92
Males		NS		0.57		0.13		NS	
Source of Var.		DF	Mean square	F	Mean square	F	Mean square	F	
Rep		7	33.89 X 10 ⁶	27.00**	11.26 X 10 ¹	15.46**	21.34 X 10 ¹	15.85**	18.53 X 10 ⁴
WP = Females		13	31.99 X 10 ⁵	2.54**	86.99 X 10 ¹	11.94**	55.66 X 10 ⁻¹	4.13**	76.83 X 10 ³
Error (A)		91	12.55 X 10 ⁵		72.85 X 10 ⁻¹		13.47 X 10 ⁻¹		15.11 X 10 ³
SP = Males		1	70.86 X 10 ⁴	NS	35.93 X 10 ¹	7.81**	15.82 X 10 ⁻¹	6.12*	16.00 X 10 ²
WP X SP		13	11.07 X 10 ⁵	2.46**	21.18 X 10 ¹	4.61**	70.94 X 10 ⁻²	2.74**	93.29 X 10 ²
Error (B)		98	45.00 X 10 ⁴		45.99 X 10 ⁻¹		25.86 X 10 ⁻²		33.39 X 10 ²
Total		223	20.28 X 10 ⁵		14.99 X 10 ¹		17.06 X 10 ⁻¹		18.47 X 10 ³

Table 2C. Performance of CMS-restorer versus Mendelian-restorer hybrids. Test 2A, Farmington, Utah, 1967.

Code	Description	Amino N PPM		Na PPM		K PPM		Beet count	
		aa	Mean	aa	Mean	aa	Mean	aa	Mean
03	CT 9 X EI 31	226	201	388	436	1557	1577	51	48
01	AI-1 X C672	224	178	431	375	1606	1505	60	56
14	308 X CT 5A	278	288	560	561	1569	1634	56	39
13	AI-1 X Ov 3	283	218	396	520	1435	1309	43	49
08	AI-1 X EI 31	227	201	526	517	1401	1366	50	60
12	308 X CT 5B	227	244	443	583	1427	1596	52	49
39	AI-1 X FC 505	211	187	351	405	1529	1471	46	52
04	308 X EI 31	241	226	561	640	1696	1585	51	55
06	AI-1 X CT 5B	251	218	376	402	1551	1453	49	51
02	129 X CT 5A	222	184	344	418	1467	1378	48	56
05	308 X Line 289	248	271	272	341	1326	1414	51	47
10	CT 9 X FC 503	222	181	388	404	1622	1525	51	58
11	AI-1 X Line 289	254	227	352	371	1431	1406	43	50
07	FC 502 X 00.5	189	222	519	568	1560	1533	47	51
Mean All Females		236	218	418	467	1513	1482	48	52
Sig. Dif. at 5%									
Males Same Female		44.50		68.49		108.96		7.37	
Females			45.0		96.42		109.72		5.64
Males		11.86		18.30		29.12		1.87	

Source of Var.	DF	Mean square		F		Mean square		F		Mean square		F	
Rep	7	13.79	X 10 ³	3.40*		30.38	X 10 ⁴	16.34**		10.02	X 10 ⁴	4.16*	25.31
WP = Females	13	10.61	X 10 ³	2.62**		12.84	X 10 ⁴	6.90**		12.89	X 10 ⁴	5.35**	18.03
Error (A)	91	40.51	X 10 ²			18.60	X 10 ³			24.08	X 10 ³		63.57
SP = Males	1	19.09	X 10 ³	9.64**		13.30	X 10 ⁴	28.35**		51.97	X 10 ³	4.38*	17.85
WP X SP	13	33.00	X 10 ²	NS		10.81	X 10 ³	2.30*		30.58	X 10 ³	2.58**	21.24
Error (B)	98	19.81	X 10 ²			46.92	X 10 ²			11.88	X 10 ³		54.38
Total	223	33.53	X 10 ²			27.90	X 10 ³			27.72	X 10 ³		81.48

Table 2D. Performance of CMS restorer versus Mendelian restorer hybrids. Test 2, Combined locations, 1967.

Code	Description	Gross sugar		Tons per acre		Percent sucrose		Index	
		aa	CMS	aa	Mean	aa	CMS	aa	Mean
03	CT 9 X EI 31	6570	6750	23.59	24.22	13.84	13.91	556	520
01	AI-1 X C672	6412	6852	23.48	24.85	13.61	13.66	587	536
12	AI-1 X Ov 3	6723	6466	24.57	23.79	13.67	13.61	625	563
04	308 X EI 31	6861	6219	26.24	24.67	13.11	12.65	688	690
08	AI-1 X EI 31	6524	6456	24.67	23.65	13.41	13.67	606	576
11	308 X CT 5B	6208	6472	23.45	24.84	13.14	12.80	560	604
02	129 X CT 5A	6294	6138	23.14	23.24	13.57	13.31	495	483
09	CT 9 X FC 503	5900	6281	21.63	22.96	13.74	13.63	538	526
06	AI-1 X CT 5B	5921	6280	21.35	23.13	13.63	13.46	551	525
05	308 X Line 289	5850	6003	20.45	21.14	14.11	14.06	549	555
07	FC 502 X 00.5	5888	5636	22.14	21.85	13.33	12.85	560	592
10	AI-1 X Line 289	5865	5651	20.98	20.34	13.86	13.63	560	590
Mean All Females		6258	6289	22.96	23.34	13.58	13.44	573	570
Sig. Dif. at 5%									
Males Same Female		358		1.14		0.28		38	
Females			400		1.08		0.42		28
Males		NS		0.24		0.06		NS	

Source of Var.	DF	Mean square		F		Mean square		F		Mean square		F
		aa	CMS	aa	Mean	aa	CMS	aa	Mean	aa	CMS	
Reps	7	.1577	X 10 ⁸	.5684	X 10 ²	.9715	X 10 ¹	.7854	X 10 ⁵			
Loc	1	.1989	X 10 ¹⁰	.2658	X 10 ⁵	.5937	X 10 ⁰	.1925	X 10 ⁵			
Error (A)	7	.1231	X 10 ⁸	.3780	X 10 ²	.8760	X 10 ¹	.8728	X 10 ⁵			
WP	11	.3605	X 10 ⁷	.7650	X 10 ²	.4219	X 10 ¹	6.08**	X 10 ⁵			8.45**
Loc X WP	11	.1139	X 10 ⁷	.1733	X 10 ²	.1972	X 10 ¹	2.84**	X 10 ⁵			3.60**
Error (B)	154	.6422	X 10 ⁶	.4739	X 10 ¹	.6941	X 10 ⁰					
SP	1	.9628	X 10 ⁵	.1408	X 10 ²	.2100	X 10 ¹	13.07**	X 10 ³			NS
Loc X SP	1	.1403	X 10 ⁷	.3889	X 10 ²	.6338	X 10 ⁰	3.94*	X 10 ⁴			2.92
WP X SP	1	.9836	X 10 ⁶	.1297	X 10 ²	.3818	X 10 ⁰	2.37*	X 10 ⁵			6.77**
Loc X WP X SP	11	.4071	X 10 ⁶	.4523	X 10 ¹	.2999	X 10 ⁰	1.87*	X 10 ⁴			2.50**
Error (C)	168	.2553	X 10 ⁶	.2615	X 10 ¹	.1607	X 10 ⁰					
Total	383	.6256	X 10 ⁷	.7752	X 10 ²	.8933	X 10 ⁰					

Table 2E. Performance of CMS restorer versus Mendelian restorer hybrids. Test 2, combined locations, 1967.

Code	Description	Amino N PPM		Na PPM		K PPM		Beet count	
		aa	Mean	aa	Mean	aa	Mean	aa	Mean
03	CT 9 X EI 31	298	281	401	399	1291	1258	56	56
01	AI-1 X C672	311	294	428	409	1334	1243	61	59
12	AI-1 X Ov 3	412	366	367	410	1245	1131	49	53
04	308 X EI 31	363	343	510	542	1406	1309	58	58
08	AI-1 X EI 31	339	312	444	448	1231	1186	55	57
11	308 X CT 5B	283	290	420	486	1216	1338	53	54
02	129 X CT 5A	244	232	335	352	1236	1168	52	54
09	CT 9 X FC 503	276	258	365	388	1366	1263	56	58
06	AI-1 X CT 5B	310	288	347	367	125	1187	53	54
05	308 X Line 289	376	370	288	320	1165	1194	54	53
07	FC 502 X 00.5	252	262	449	487	1313	1331	52	53
10	AI-1 X Line 289	350	369	347	364	1187	1235	49	54
Mean All Females		317	294	392	414	1270	1237	54	55
Sig. Dif. at 5%									
Males Same Female		36		42		63		65	
Females		30		56		63		65	
Males		8		9		13		13	
Source of Var.	DF	Mean square		Mean square		Mean square		Mean square	
		F	F	F	F	F	F	F	F
Reps	7	.6679 X 10 ⁴		.1405 X 10 ⁶		.8875 X 10 ⁵		.5084 X 10 ³	3.48
Loc	1	.2518 X 10 ⁷	134.74**	.2197 X 10 ⁶		.2122 X 10 ⁸	362.25**	.5844 X 10 ⁴	40.01**
Error (A)	7	.1868 X 10 ⁵		.1573 X 10 ⁶		.5859 X 10 ⁵		.1461 X 10 ³	
WP	11	.7064 X 10 ⁵	18.78**	.1356 X 10 ⁶	10.55**	.1113 X 10 ⁶	6.59**	.2699 X 10 ³	4.08**
Loc X WP	11	.3262 X 10 ⁵	8.67**	.2719 X 10 ⁶	21.17**	.5477 X 10 ⁵	3.24*	.5431 X 10 ²	
Error (B)	154	.3762 X 10 ⁴		.1285 X 10 ⁵		.1688 X 10 ⁵		.6622 X 10 ²	
SP	1	.5157 X 10 ⁵	20.64**	.1993 X 10 ⁶	54.33**	.1061 X 10 ⁶	13.25**	.3154 X 10 ³	7.53**
Loc X SP	1	.2871 X 10 ⁴	1.15	.1768 X 10 ⁴		.1085 X 10 ³		.1525 X 10 ³	3.64
WP X SP	11	.1005 X 10 ⁵	4.02*	.1627 X 10 ⁵	4.48**	.4240 X 10 ⁵	5.30**	.6263 X 10 ²	1.50
Loc X WP X SP	11	.3792 X 10 ⁴	1.52	.8475 X 10 ⁴	2.31*	.1097 X 10 ⁵	1.37	.6104 X 10 ²	1.46
Error (C)	168	.2499 X 10 ⁴		.3668 X 10 ⁴		.8003 X 10 ⁴		.4861 X 10 ²	
Total	383	.1315 X 10 ⁵		.1870 X 10 ⁵		.7498 X 10 ⁵		.8629 X 10 ²	

Linkage Tests With The a₁ Male-sterile Gene And
Other Mendelian Characters in Beta vulgaris L.

J. C. Theurer

Knowledge of associations between genetic characters is extremely useful to plant breeders as well as being of academic interest. In some field crops, such as maize or barley, extensive linkage data are available. Information on the nine linkage groups in sugarbeets, however, is very meager. In fact, only four genes, hypocotyl color (R), yellow pigment (Y), annual growth habit (B), and monogerm (m), have received intensive study.

In 1936, Keller (4) found an allelic series for the R and Y genes and demonstrated a close linkage between them. Abegg and Owen (3) reported an association of the R gene and a partially dominant factor (C) for curly-top resistance. Abegg (1) published linkage data for R and B association and noted independence of the plantain-like leaf mutant (pl). These conclusions were later verified by other research workers (9, 10). A recessive dwarf mutant with crinkled foliage (cr) has also been identified with the Y-R-B linkage group (2).

The self-fertile gene (S^f), russet root (ru), black root (bl), Mendelian male sterility (a₁), monogerm (m) and cytoplasmic male-sterility factors (X and Y) have shown independence from the Y-R-B group (6, 7, 8, 10).

Savitsky (11) observed linkage between the m gene and a gene conditioning slow bolting which was not allelic to the annual gene B. He also noted an association with a factor for curly-top resistance and m (13). Owen (8) observed independent segregation for monogerm and the a₁ genes.

A variegated mutant (y₁) is associated with the Y-R-B linkage group (10), and a recently studied lutescens (lu₂) mutant shows independence of these genetic factors (14).

The results reported herein are part of a long-term study to delineate linkage groups in Beta vulgaris L. particularly in regard to associations of genetic characters with genic or genic-cytoplasmic types of male sterility.

MATERIALS AND METHODS

Genetic material used in this study was secured from diverse sources. The Y (yellow pigment), tr (trout leaf) and ru (russet root) factors were available from a previous linkage study conducted at Salt Lake City, Utah (10). Red (R) and green (r)

hypocotyl, m (monogerm) and M (multigerm) seed, and a₁ (Mendelian male sterility) characters are common in sugarbeet varieties and were taken from our current breeding stocks of SLC 129 and CT 5. An S₂ increase of a dwarf mutant, which was observed in the nursery at Salt Lake City in 1957, was the source of the dwarf (d) gene. This line was also carrying the B (annual growth habit) factor. Lutescens (lu₂) was a mutant isolated from C-019, a line received in 1966 from Mr. Charles Price, USDA, Agricultural Research Service, Salinas, California.

Description of Characters

a₁—Mendelian male sterility (8). This is a simple recessive designated a for abortion of pollen. Flowers contain white to greenish-white shrunken anthers in the bud stage which become brown after anthesis and are devoid of pollen. Stigma and other female parts of the flower are normal.

B—Annual growth habit (1, 10). Plants with the dominant B allele bolt and produce seedstalks in an environment of 18-24 hour photoperiods and 75-80 F. Homozygous bb plants remain vegetative under the same conditions. Additional modifying factors, not at the B locus, sometimes cause variation in bolting tendency which makes it difficult to classify plants for annual habit. This temperature-sensitive character is linked with the R and Y genes.

d—Dwarf. Seedling plants have thick shortened hypocotyls but are equal in vigor to normal plants. Mature plants are diminished in size in all respects and have a thick rosette of leaves with decumbent growth. Seedstalks are only three to four inches high but can be elongated by treatment with gibberellic acid.

lu₂—Lutescens (14), a lethal recessive chlorophyll deficiency. Cotyledons are green in color, but all true leaves of the seedling plant are yellow. When the nutrients of the cotyledons are depleted, the plant dies.

m—Monogerm (11, 12). A recessive character wherein plants have single-germ fruits and seeds and a different type of branching than other Beta. Either a lateral branch or a single fruit can be borne in the axil of a leaf but never both together. Four multigerm alleles (M, M¹, M^{Br}, M²) show different degrees of dominance over m. Homozygous mm plants can be modified by non-allelic genes causing the appearance of a few double-germ fruits on the main branch of the inflorescence. It is associated with a late-bolting tendency.

R—Red Pigment (3, 10). A single gene consisting of an allelic series (R, R^t, R^P, r) which govern color of hypocotyl, root and foliage. R alleles are dominant to r, giving red color to hypocotyls of seedlings and crown buds of older plants. R^t results in intense pigment extending red striped into the base of the petioles.

R^P shows pink petioles as well as hypocotyl color. Pigment sometimes fades completely out when a plant initiates a seed stalk. R is linked with B and Y genes.

ru—Russet root (10). A rough corky tissue developed on the epidermis of roots giving them a tan to brown color. It is inherited as a simple recessive but shows variation in intensity of pigmentation. It has been reported to be easily classified under field conditions but more difficult to classify under greenhouse conditions.

Tr—Trout or spotted leaf (10). This shows red pigmented spots in the leaf with R and yellow pigment with r. Pigment is more intense in the first true two-leaf stage of development and on the under surface of the leaf. Tr r plants are difficult to classify as are older Tr plants. Considerable inter-plant variation in the intensity of pigmentation is observed and spots on older leaves may be difficult to see.

Y—Yellow pigment (4, 10). A single factor allelic series with Y and Y^r alleles dominant to y. It is hypostatic to the R gene and incites heavy production and extension of red pigment with R alleles and yellow to orange with r. Pigment is observed in the root and also in the foliage, especially in the midrib of the petiole and larger veins. Variation in expression due to environmental factors and accessory factors has been noted. It is in the same linkage group as R and B.

In February, 1965, appropriate crosses were made in the greenhouse by exchanging paper bags over the inflorescences. Mendelian male-sterile plants were used for the female parents enabling us to obtain F₁ hybrid seed without emasculation. Seed of each cross was planted in peat cups in the greenhouse June 1, classified for seedling characteristics two weeks later, and transferred to cold storage for induction in August. In early 1966, backcrosses were made where possible utilizing the homozygous double recessive as the recurrent parent and the F₁ plants as pollinators. F₂ seedlings in peat cups were transplanted to the field in June. In September all plants were removed from the field and transferred to a cold chamber for photothermal induction. Subsequently, they were classified for fertility and root color and other characters in the greenhouse. Dwarf plants in all generations were sprayed at four-day intervals with 300 ppm gibberellic acid to elongate seedstalks.

χ^2 statistics were utilized to determine the significance of deviations between observed and theoretical Mendelian ratios and for the purpose of revealing association or linkage between respective genes. Linkage intensities and standard deviations between the R and Tr genes were determined by utilizing Mather's formulas for maximum likelihood (5).

RESULTS AND DISCUSSION

χ^2 tests for linkages and deviations in Mendelian ratios for the \underline{a}_1 gene and other genetic factors are shown in Table 1. \underline{X} and \underline{Y} (column 1) denote the respective factors in the cross, \underline{CF}_2 , \underline{CB} and \underline{RF}_2 (column 2) represent F_2 coupling, backcross coupling, and F_2 repulsion phases of the linkage test, respectively. The first seven lines of the table represent F_2 and b_1 segregations of \underline{a}_1 and genes known to be linked in the \underline{Y} - \underline{R} - \underline{B} group. A good fit is observed for \underline{Y} , \underline{R} , and \underline{B} with \underline{a}_1 indicating independence of the male-sterility factor from this linkage group. In the F_2 , the \underline{Tr} gene segregation shows significance for the $\chi^2_{1\text{d.f.}}$ value. However, this was probably just a chance occurrence since the backcross data showed definite independence. The significant χ^2_{X} for \underline{Tr} in the F_2 can probably be explained on the basis that some plants which were \underline{Tr} were classified as normal because the mild expression of spotting was not recognized on these older plants. These data confirm Owen's (8) observations that \underline{R} and \underline{Tr} are not linked with the \underline{a}_1 gene.

The balance of Table 1 shows segregation for \underline{m} , \underline{ru} , \underline{d} , and \underline{lu}_2 genes with \underline{a}_1 . Apparently all four of these factors are also independent of the linkage group associated with Mendelian male sterility. A poor fit was observed for monogerm F_2 segregation as indicated by the χ^2_{X} value. Some difficulty was experienced in classifying plants which had considerable double germs. It is possible that the deficiency in monogerm segregates could be attributed to the effects of modifying factors as pointed out by Savitsky (11).

Since the \underline{lu}_2 gene is lethal in the seedling stage, only \underline{Lu}_2 plants were available for fertility classification. The excellent fit to the expected 3:1 ratio of fertile to male-sterile offspring indicated lack of association of these genes, otherwise there would have been significantly more sterile segregates than observed in this repulsion cross.

Table 2 shows χ^2 values for tests of linkage and fit to independent ratios for five genes and the factor \underline{R} . A highly significant $\chi^2_{1\text{d.f.}}$ value for \underline{Tr} and \underline{R} shows that these factors are associated on the same chromosome. The four other factors gave good fit to independent ratios. The recombination percentage obtained for the F_2 was slightly lower and the b_1 was higher than values reported by Owen and Ryser (10). The average value, however, fits fairly close to the average recombination percentage determined by these workers.

Segregation and χ^2 tests of deviations for the monogerm factor and five other genes are listed in Table 3. The $\chi^2_{1\text{d.f.}}$ value was nonsignificant for all factors except \underline{ru} , which exceeded the 5% point. This was probably a matter of chance deviation or caused by misclassification rather than linkage as might be

Table 1. χ^2 tests for linkages and deviations in Mendelian ratios for \underline{a}_1 and other genetic factors.

Genes (XY)	Linkage phase	No. families	Number of individuals					$\chi^2_{\underline{X}}^*$	$\chi^2_{\underline{Y}}^*$	$\chi^2_{\underline{L}}^*$
			XY	Xy	xY	xy	total			
$\underline{R} \underline{a}_1$	CF	6	856	317	298	104	1575	0.23	2.51	0.20
	CB	4	110	127	140	124	501	1.46	0.0002	2.17
$\underline{Y} \underline{a}_1$	CF	1	399	137	151	44	731	1.10	0.02	0.72
	CB	1	33	31	40	35	139	0.87	0.35	0.07
$\underline{TR} \underline{a}_1$	CF	2	145	68	74	17	304	3.95	1.42	5.99
	CB	1	22	16	19	9	66	1.52	3.88	0.24
$\underline{B} \underline{a}_1$	CB	1	4	8	7	7	26	0.15	0.62	0.62
$\underline{m} \underline{a}_1$	CF ₂	5	1002	322	209	95	1628	34.75	0.33	3.27
	CB ₂	3	57	51	43	39	190	3.56	0.52	0.02
$\underline{ru} \underline{a}_1$	RF ₂	2	319	119	92	23	553	5.21	0.14	2.30
$\underline{d} \underline{a}_1$	RF ₂	1	41	19	25	4	89	6.54	2.73	3.78
$\underline{lu}_2 \underline{a}_1$	RF ₂	1	207	57	---	---	264	----	1.64	----

* A value of 3.841 is required for 5% point of significance and 6.635 for 1% point of significance.

Table 2. χ^2 tests for linkages and deviations in Mendelian ratios for R and other genetic factors.

Genes (XY)	Linkage phase	No. families	Number of individuals					χ^2_{X} *	χ^2_{Y} *	χ^2_{L} *	Recombination percentage
			XY	Xy	xY	xy	total				
<u>Tr</u> <u>R</u>	CF	2	210	6	3	85	304	2.53	6.95	328.47	2.83 \pm 0.69
	CB	1	43	7	0	26	76	7.58	1.32	50.58	9.21 \pm 3.32
<u>m</u> <u>R</u>	CF	3	442	143	120	44	749	3.85	0.0004	0.36	
	CB	3	65	49	79	54	247	6.81	1.46	0.33	
<u>ru</u> <u>R</u>	RF ₂	2	318	120	93	22	553	5.21	0.14	3.04	
<u>d</u> <u>R</u>	RF ₂	1	278	92	105	27	502	0.45	0.45	1.09	
<u>lu</u> ₂ <u>R</u>	RF ₂	1	129	38	44	22	233	1.38	0.07	3.12	

* A value of 3.841 is required for 5% point of significance and 6.635 for 1% point of significance.

Table 3. χ^2 tests for linkages and deviations in Mendelian ratios for \underline{m} and other genetic factors.

Genes (XY)	Linkage phase	No. families	Number of individuals					$\chi^2_{\underline{X}}$ *	$\chi^2_{\underline{Y}}$ *	$\chi^2_{\underline{L}}$ *
			XY	Xy	xY	xy	total			
$\underline{R} \underline{m}$	CF	3	442	120	143	44	749	0.0004	3.85	0.36
	CB	3	65	79	49	54	247	1.46	6.81	0.33
$\underline{Y} \underline{m}$	CF ₂	1	452	84	166	29	731	1.10	35.50	0.21
	CB ₂	1	33	31	45	30	139	0.87	2.08	1.22
$\underline{Tr} \underline{m}$	CF ₂	1	129	18	54	5	206	1.46	21.03	0.95
	CB ₂	1	33	5	22	6	66	1.52	29.33	2.18
$\underline{ru} \underline{m}$	RF ₂	1	149	75	45	10	279	4.16	4.45	5.83
$\underline{lu}_2 \underline{m}$	RF ₂	1	208	56	---	--	264	2.02	-----	----

* A value of 3.841 is required for 5% point of significance and 6.635 for 1% point of significance.

indicated by the chi-square. Since neither the ru nor the m genes gave a good fit to expected 3:1 ratios, this linkage test is not valid.

The data supports Owen's (8) conclusion that the monogerm factor is not linked with genes in the Y-R-B group.

The reader will note that χ^2_y values were high for the various crosses denoting a poor fit to a 3:1 expected ratio for monogerm segregation. Difficulty experiences in classifying plants which had both single and double-germ fruits could account for much of this discrepancy. Savitsky (11) observed that modifying genes not associated with the M gene caused homozygous mm plants to develop double-germ fruits on the basal part of the main floral axis just above the lateral branches and on the basal part of some of the lateral branches. In some F_2 families he observed that 30% to 70% of the monogerm plants produced some double-germ fruits.

Based upon the results of this study and earlier experiments (1, 3, 4, 8, 10, 11, 13), five linkage groups can be established for Beta vulgaris L. These are shown in Table 4. Group I, known as the Y-R-B group, consists at present of eight genes and is by far the largest and most well-known group. The recombination percentages determined by Owen and Ryser (10) have made it possible to construct a linkage map of this group (Fig. 1). Three genes, Tr, Cl, and Cv are so closely related that their exact order has not been determined. Alternatively these three factors may be allelic since they have recombination percentages with no greater variance than that observed between the R gene and other factors. In the present study, some of the segregates carrying the trout-leaf gene were so heavily pigmented that it would be difficult to separate them from Cl plants. Others were difficult to classify because of lack of expression of the character.

The C gene for curly-top resistance, which is associated with group I, needs confirmation. Tentatively it is placed to the left of Y, but inasmuch as only the association with R has been reported (3), it could just as well be located proximal to y₁.

Linkage group II is known to contain three factors: the monogerm gene which consists of a multiple allelic series (12), a late bolting factor located 25 crossover units from m (11), and a curly-top resistance factor which has been reported associated with m (13) but which has not been critically studied.

The other three linkage groups, III, IV and V, each consist of a single marker gene which shows independence of the four other groups with one exception. Further evidence is required to be positive that lu₂ and ru are independently inherited.

The above data summarize knowledge of linkage associations in sugarbeets at the present time. Experiments are currently under way

Table 4. Linkage groups in Beta vulgaris L.

Linkage group	Genetic symbols	Character
I.	Y, Y ^r , y R, R ^t , RP, r Cl, cl Tr, tr Cv, cv B, b v ₁ , V ₁ C, c cr, Cr	Yellow pigment Hypocotyl color Colored leaf Trout leaf Colored vein Annual growth habit Variegated foliage Curly-top resistance Crinkled foliage
II.	m, M ¹ , M ^{Br} , M, M ^Z (1b)* (C ₂)*	Monogerm seed Late bolting Curly-top resistance
III.	a ₁ , A ₁	Mendelian male-sterility
IV.	lu ₂ , Lu ₂ †	Lutescens
V.	ru, Ru †	Russet root

Other characters independent of linkage group I, but not tested for linkage with groups II to IV.

bl, Bl	Black root
d, D †	Dwarf
pl, Pl	Plantain leaf
s, S ^s	Self fertility

* Symbol assigned in accord with other known genetic symbols. None given for the character by the authors who observed the linkage.

† Independence of these two characters has not been established.

‡ Also not linked with group III.

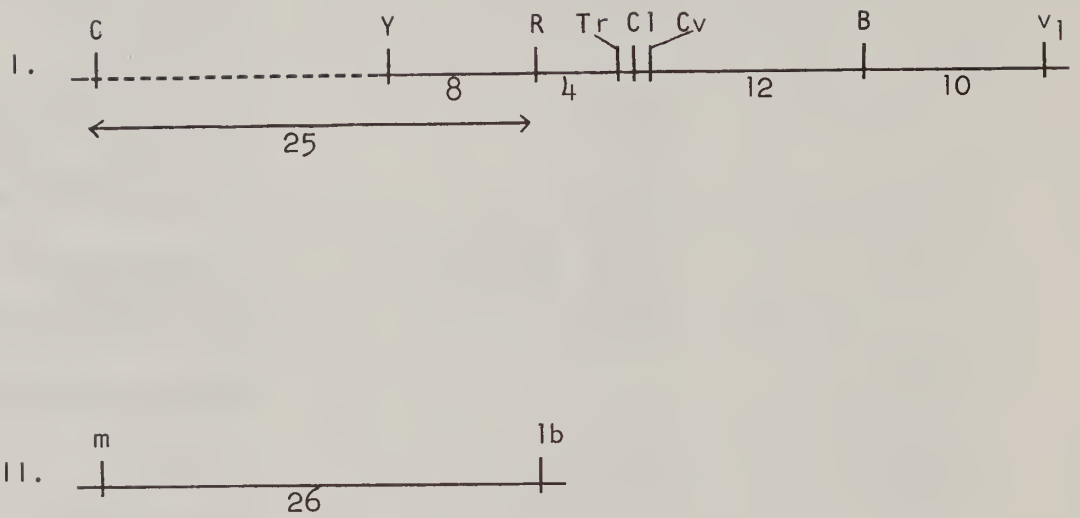


Figure 1. Map of Y-R-B linkage group (I) and monogerm linkage group (II) showing average recombination percentages between the genes.

to test the association of p₁, d and other mutants with the five groups cited in Table 4. Association also is being studied with these linkage groups and another Mendelian male-sterility gene (a₂), and will be reported in due time.

SUMMARY

Linkage tests involving nine genetic factors in Beta vulgaris L. were studied in the greenhouse. The a₁ gene responsible for Mendelian male sterility showed independent inheritance from all other factors. Linkage between red hypocotyl color (R) and trout leaf (Tr) and lack of association of monogerm (m) and russet root (ru) with the Y-R-B linkage group, as noted by other research workers, was confirmed. The dwarf factor (d) and lutescens (lu₂) were observed to be independent of the Y-R-B group. The ru and lu₂ characters are not associated with m. A summary table of linkage groups in sugarbeets and linkage maps for two of these groups are presented.

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P A R T IV

Progress reports of research conducted at
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DEVELOPMENT AND EVALUATION OF SUGARBEET BREEDING
MATERIAL AND VARIETIES CARRYING RESISTANCE TO
LEAF SPOT AND CURLY TOP, 1967 1/

John O. Gaskill, David L. Mumford, and Gerald E. Coe 2/

Breeding for combined resistance to leaf spot and curly top (LSR-CTR) at Fort Collins, Colorado, and evaluation of LSR-CTR material at Fort Collins and elsewhere in 1967, in general, followed the plan of the preceding year (2)3/. This report is intended as a summary of results of the more important evaluation tests of 1967. Details regarding plant selection and breeding work, results of preliminary leaf spot resistance evaluation of breeding lines, results of service tests, etc., have been largely omitted.

1/ This progress report pertains to breeding and evaluation work conducted at Fort Collins, Colorado, and to cooperative tests conducted elsewhere by various investigators, with results compiled at the Fort Collins Station. The work at Fort Collins was performed by the Crops Research Division, A.R.S., U.S.D.A., in cooperation with the Colorado Agricultural Experiment Station (Project 149) and the Beet Sugar Development Foundation (Project 25). Assistance rendered by Luther W. Lawson and Beverlie A. Nelsen, Agricultural Research Technician and Statistical Clerk, respectively, Crops Research Division, in conducting breeding, evaluation, and other work at Fort Collins is acknowledged. Participation by other investigators in the research program covered by this report is acknowledged in the tables and accompanying discussion.

2/ Research Plant Pathologist, Plant Pathologist, and Geneticist, respectively, Crops Research Division, A.R.S., U.S.D.A.

3/ Numbers in parentheses pertain to Literature Cited.

High Lights of Accomplishments

1. Results of a reciprocal top-cross test (Exp. 5A, 9 replications) under severe leaf spot exposure on the Hospital Farm at Fort Collins, indicated that one of the new, LSR-CTR, monogerm, type-0 inbred lines (SP 652016sl, a subline of FC 601) is high in combining ability for root yield. The hybrid, FC 901 aa ♀ x SP 652016sl, exceeded the standard variety, SL(129 x 133) x SP 6322-0, in yield of roots and gross sucrose by 21.3 and 22.9 percent, respectively. These differences were highly significant. FC 901 aa ♀ x SP 652016sl also was above the standard variety in sucrose percentage, but the difference was not significant. Results obtained at Fort Collins and at Thatcher, Utah, in 1967 confirmed earlier evidence that SP 652016sl is high in resistance to both leaf spot and curly top.
2. Results of a top-cross test (Exp. 2A, 8 replications) at Fort Collins supported earlier evidence (1) that the LSR-CTR, monogerm, type-0, inbred line, SP 632028sl, is high in combining ability for root yield and sucrose percentage. In Experiment 2A, the hybrid, SP 632028sl-CMS x FC 901, exceeded the standard variety, SL(129 x 133) x SP 6322-0, by 19.8, 14.7, and 4.3 percent in gross sucrose yield, root yield, and sucrose percentage, respectively. Each of these differences was highly significant.
3. The top-cross test, Experiment 2A (see above), included hybrids of each of 10 CMS females with each of 4 pollinators--a total of 40 hybrids. The outstanding hybrids in this entire set were those having FC(504 x 502/2)-CMS as the female parent. The respective hybrids having this female as a parent were highest in gross sucrose yield among all of the hybrids of the corresponding pollinator lines. The average gross sucrose yield of all 4 hybrids of FC(504 x 502/2) exceeded the corresponding average of the 4 hybrids of the nearest competitor female by 8.4 percent, a highly significant difference. The average gross sucrose yield of the 4 hybrids of FC(504 x 502/2)--i.e. 5289 pounds per acre--may be compared with an average of 4119 pounds for the standard variety, SL(129 x 133) x SP 6322-0. The difference between these two averages is far in excess of the 1-percent level of significance. Each of the 4 hybrids of FC(504 x 502/2) was significantly higher in sucrose percentage than the standard variety.
4. Results of a test of reciprocal top-cross hybrids at Fort Collins (Exp. 3A, 7 replications) and an observational test at Thatcher, Utah, strongly indicated that genotypes with superior combining ability for root and gross sucrose yield can be extracted from the heterogeneous pollinator variety, FC 901, without detriment to sucrose percentage capabilities or resistance to leaf spot and

curly top. There was some evidence that combining ability for sucrose percentage and leaf spot resistance can be improved in the process.

5. In 4 cooperative agronomic tests of LSR-CTR varieties in the eastern area of the United States (Iowa, Maryland, and Minnesota), the standard variety, SL(129 x 133) x SP 6322-0, was outstanding in gross sucrose yield. In 7 comparable tests in the western area (California, Colorado, Kansas, and Texas), the following entries were outstanding in gross sucrose yield: entry 3 [SP 65406-01 x FC 901], entry 5 [FC(504 x 502/2) x FC 901], and entry 6 [FC(504 x 502/2) x McF. 663]. In sucrose percentage, in the western area, entry 3 was disappointing, entry 6 was slightly above the standard variety, and entry 5 was definitely superior.

Preliminary, Disease Resistance Evaluation
of LSR-CTR, Monogerm, Type-0, Inbred Lines

Forty eight S₁, S₂, or S₃ monogerm lines, classed as type-0 or near type-0 and having a background of breeding for resistance to both leaf spot and curly top, were given preliminary evaluation for resistance to both diseases in 1967. The seed used had been obtained by selfing with one or two paper bags per plant. About 1 gram of seed per line was used by Dr. D. L. Mumford at Logan, Utah, for curly top resistance comparisons in the greenhouse. Leaf spot resistance comparisons were made in the field at Fort Collins, Colorado (Exp. 6A). Techniques and results are summarized in Table 1.

Eighteen of the lines in this test were at least equal to SP 5481-0 (an LSR check) and to US 41 (the CTR check) in apparent resistance to leaf spot and curly top, respectively.

Table 1.--Evaluation of leaf spot and curly top resistance of monogerm, type-0 and near type-0, inbred lines of sugarbeet, Fort Collins, Colorado, and Logan, Utah, 1967.

Description and/or source	: Immediate parent	: Line no. (seed no.)	: No. :gen. :self.	: Pol. :rating	: a/ : b/ : rating	: Fort Collins Exp. no. 6A	: Entry:No. of: Leaf spot	: 8/24 : 9/5 : 8/7	: 6A	: 8/7	: Code : no.	Logan Greenhouse d/			
												: Inoc. : no.	: Inf. : no.	: Curly top : no.	: b/
SP 611100-0; SP 622075s1	SP 642027s1	SP 662000s1	3	4	100/0	401	2	2.0	3.0	4.5	67C-111	16	69	92	
" " ; " "	" "	" 662002s1	3	5	100/0	402	2	1.3	2.0	4.5	" -112	8	89	100	
" " ; " "	" "	" 662004s1	3	5	100/0	404	1	1.5	2.0	5.0	" -113	6	17	100	
" " ; " 631101-0A	" 642005s1	" 662005s1	2	6	100/0	405	2	1.8	3.0	5.5	" -114	13	77	113	
" " ; " "	" "	" 662015s1	2	5	91/4	406	2	2.3	3.8	5.5	" -115	12	58	90	
" " ; " "	" "	" 662032s1	2	6	100/0	408	2	1.8	3.0	5.5	" -116	16	69	100	
" " ; " "	" 642048s1	" 662025s1	2	5	100/0	414	2	2.3	3.3	5.5	" -117	12	83	110	
" " ; " "	" 642082s1	" 662003s1	2	4	90/5	418	1	1.5	2.0	5.0	" -118	13	69	103	
" " ; " "	" 642089s1	" 662013s1	2	4	95/0	424	2	1.5	1.8	5.0	" -119	16	81	97	
" " ; " " ; CTR Sel. by A.M.M.	Acc. 2617	" 662048s1	1	6	100/0	426	2	1.3	1.8	4.5	" -120	15	87	95	
SP 611101-0; SP 622071s1(FC 601)	SP 642056s1	" 662001s1	3	4	100/0	428	2	2.8	3.5	4.0	" -121	12	42	100	
" " ; " " (" ") ; CTR Sel. by C.W.B.	" 641157-(02)	" 662092s1	2	6	100/0	431	1	1.0	1.5	4.0	" -122	8	75	95	
" " ; " " (" ") ; " " " "	" "	" 662107s1	2	5	100/0	433	1	2.5	3.0	5.0	" -123	16	31	93	
SP 611100-0 & SP 611101-0; SP 622108s1 & SP 622067s1;	" 641157-(001)	" 662073s1	1	5	96/4	438	2	2.0	3.0	5.0	" -124	15	33	73	
CTR Sel. by C.W.B.	" "	" 662109s1	1	5	96/0	442	2	2.8	2.8	4.5	" -125	16	31	113	
do.	" "	" 662110s1	1	5	100/0	444	2	2.8	3.5	5.0	" -126	12	17	83	
do.	" "	" 662138s1	1	5	95/5	446	2	2.0	2.3	5.0	" -127	15	27	100	
SP 611227-(001)	" 642077s1	" 662020s1	2	4	100/0	448	2	1.8	2.5	5.5	" -128	18	89	112	
" " ; " "	" "	" 662024s1	2	5	100/0	449	1	1.0	1.5	5.0	" -129	19	100	108	
" " ; " "	" "	" 662026s1	2	3	100/0	450	1	1.5	2.0	5.0	" -130	20	90	118	
" " ; " "	" "	" 662046s1	2	6	100/0	451	2	2.8	3.0	4.5	" -131	18	72	120	
" " ; " "	" "	" 662051s1	2	6	100/0	453	1	3.0	3.5	4.0	" -132	19	100	112	
" " ; " " ; SP 631103-0; CTR Sel. by C.W.B.	" 642047s1	" 662023s1	2	6	96/0	456	2	2.5	3.3	4.0	" -133	11	91	88	
" " ; " " ; " " " "	" "	" 662031s1	2	5	100/0	458	2	2.3	3.8	5.0	" -134	17	100	90	
" " ; " " ; " " " "	" "	" 662058s1	2	5	91/0	460	1	3.0	3.5	4.0	" -135	20	90	106	
" " ; " " ; " " " "	" "	" 662060s1	2	4	100/0	462	1	1.5	2.0	5.0	" -136	19	100	96	
" " ; " " ; " " " "	" "	" 662094s1	2	5	96/0	464	2	1.5	2.0	4.0	" -137	19	100	98	
" " ; " " ; " " " "	" "	" 662100s1	2	6	100/0	466	2	3.0	3.8	4.5	" -138	20	85	96	
" " ; " " ; " " " "	" 642079s1	" 662035s1	2	4	100/0	468	1	2.0	3.5	4.0	" -139	18	89	118	
" " ; " " ; " " " "	" "	" 662057s1	2	6	86/0	470	2	1.8	2.5	4.5	" -140	17	100	110	
" " ; " " ; " " " "	" "	" 662059s1	2	5	100/0	472	2	2.3	2.8	4.0	" -141	17	94	92	
" " ; " " ; " " " "	" "	" 662064s1	2	5	100/0	474	2	1.8	2.3	4.5	" -142	18	100	106	
" " ; " " ; " " " "	" 642097s1	" 662055s1	2	6	91/4	477	2	2.5	2.8	5.5	" -143	19	89	134	
" " ; " " ; " " " "	" "	" 662097s1	2	5	100/0	480	1	4.0	4.5	5.0	" -144	17	94	116	
SP 621103-0; S lines (Pool)	" 641183H00	" 662036s1	1	4	100/0	482	2	3.8	4.5	4.0	" -145	20	90	110	
" " ; " " (" ")	" "	" 662083s1	1	5	100/0	486	1	3.0	3.5	5.0	" -146	19	89	108	
SP 621233-01A; CTR Sel. by A.M.M.	Acc. 2618	" 662077s1	1	5	90/10	489	2	2.0	2.8	5.5	" -147	20	80	108	
" " ; " " ; " " " "	" "	" 662141s1	1	5	95/5	496	1	2.5	3.0	5.0	" -148	20	45	100	
" 621233-02A; " " " "	" 2619	" 662087s1	1	6	100/0	500	1	2.5	3.0	4.0	" -149	8	38	90	
" " ; " " ; " " " "	" "	" 662095s1	1	5	100/0	501	1	2.0	2.5	5.0	" -150	20	40	88	
C2563 x SP 611227-(001) (C2563 cytoplasm)	SP 641185-001	" 662072s1	1	5	100/0	505	1	4.0	5.0	5.0	" -151	19	95	108	
do.	" "	" 662088s1	1	5	100/0	506	2	3.0	4.3	5.0	" -152	15	87	106	
do.	" "	" 662116s1	1	5	100/0	510	2	4.3	6.0	4.5	" -153	17	59	112	
do.	" "	" 662117s1	1	6	95/0	512	2	3.0	4.3	5.0	" -154	14	57	104	
do.	" "	" 662119s1	1	5	100/0	514	1	3.0	4.0	4.0	" -155	14	14	96	
do.	" "	" 662124s1	1	5	100/0	518	2	3.5	4.5	5.0	" -156	20	30	110	
do.	" "	" 662128s1	1	5	93/0	520	2	3.0	4.0	5.5	" -157	19	89	104	
do.	" "	" 662139s1	1	5	100/0	523	2	3.0	4.0	4.5	" -158	20	80	104	
SP 5481-0 (LSR-BRR; CT sus.)	Acc. 2483	" 534	9	2.9	3.7	6.0	" -159	18	100	133					
SP 5822-0 (LSR)	" 2644	" 535	3	1.8	2.2	5.3									
Synthetic check (LSS)	" 2269	" 536	3	5.0	5.8	4.7									
US 41							" -160	56	73	100					

a/ Quantity of pollen (per flower) shed by the individual plant that was selfed to produce the indicated seed no. Basis of grades: 1-7 in ascending order of abundance (ordinary, open-pollinated, commercial variety usually rated 6 or 7).

b/ Pertains to the indexing population (usually 20 or more plants); left number is percentage classed as male sterile; right number is percentage classed as male fertile; percentage unaccounted for, if any, represents intermediate types.

c/ Field plots on Hospital Farm, Fort Collins, Colorado; inoculation and frequent sprinkling used to promote leaf spot development; plots 1 row x 20', flanked uniformly by rows of a leaf spot susceptible line.

d/ Curly top resistance evaluation by D. L. Mumford, Logan, Utah, using a virulent isolate of the curly top virus and 2 caged leafhoppers per plant.

e/ Leaf spot grades (B.A. Nelsen): 0 = no leaf spot; 10 = complete defoliation.

f/ Foliage vigor (B. A. Nelsen): Larger no. = greater vigor.

g/ Only those plants showing curly top symptoms were classed as infected.

h/ Curly top grade (D.L. Mumford) expressed as percent of the grade for US 41, disregarding plants without curly top symptoms. Basis of grades: 0 = healthy; 9 = dead.

Intermediate Evaluation of LSR-CTR, Monogerm, Type-0, Inbred Lines

Eight LSR-CTR, monogerm, type-0 or near type-0, S_2 lines were evaluated as follows:

1. Leaf spot and curly top resistance comparisons were made for the inbred lines, per se, in field tests at Fort Collins, Colorado (Exp. 11A) and near Thatcher, Utah.
2. A reciprocal top-cross test (Exp. 5A) at Fort Collins was used for preliminary appraisal of the eight lines for combining ability for root yield and sucrose percentage; also to obtain additional information regarding leaf spot resistance. The hybrids in Experiment 5A also were evaluated for curly top resistance near Thatcher, Utah.

The results of Fort Collins Experiment 11A and the corresponding material at Thatcher are presented in Table 2. The results for the reciprocal top-cross hybrids (Fort Collins Exp. 5A plus Thatcher) are shown in Table 3. Essential technique information also is given in Tables 2 and 3.

The high light of results presented in Tables 2 and 3 is the performance of the line, SP 652016sl. As an inbred, it was shown to be high in both leaf spot and curly top resistance (Table 2). The hybrid, FC 901 aa ♀ x SP 652016sl, was outstanding in yield of roots and gross sucrose (Table 3). That hybrid exceeded the standard variety, SL(129 x 133) x SP 6322-0, in yield of roots and gross sucrose by 21.3 and 22.9 percent, respectively. Both of these differences were highly significant. FC 901 aa ♀ x SP 652016sl also was above the standard variety in sucrose percentage, but the difference was not significant. Like its male parent, FC 901 aa ♀ x SP 652016sl was high in resistance to both leaf spot and curly top. SP 652016sl, a subline of FC 601, apparently is completely type-0.

Table 2 .--Disease resistance evaluation of LSR-CTR, monogerm, type-0 (+), inbred lines, Fort Collins, Colorado, and Thatcher, Utah, 1967 (see Exp. 5A for agronomic performance of hybrids having these inbreds as the ♂ parents).

: F.C.exp.11A, (3-plot av.) a/ : Thatcher, Utah b/										
Description &/or source	:Fort Collins:		Entry:		Leaf spot		c/ : d/ :		Code : Curly top	
	: seed no.		: no. :		: no. :		: no. :		: % :Grade e/	
			: no. :8/21:8/27:9/6 :		8/21 :		67C- :		8/16: 9/25	
SP 652070s1; LSR-CTR,mm,T.O.(+),R&r,S ₂ ; SP 611101-0; SP 632072s1	SP 6711151HO	551	1.5	2.8	3.3	5.0	-83	14	2.0	
SP 652014s1; LSR-CTR,mm,T.O.(+),rr,S ₂ ; sub-1. of FC 601	SP 6711152HOA	552	0.5	1.0	1.5	4.3	-84	10	2.0	
SP 652016s1; LSR-CTR,mm,T.O.(+),rr,S ₂ ; sub-1. of FC 601	SP 6711153HO	553	0.7	1.5	1.7	5.0	-85	15	2.5	
SP 652017s1; LSR-CTR,mm,T.O.(+),rr,S ₂ ; sub-1. of FC 601	SP 6711154HOA	554	0.5	1.2	1.7	4.7	-86	11	2.5	
SP 652005s1; LSR-CTR,mm,T.O.(+),rr,S ₂ ; SP 621103-0; SP 632025s1	SP 6711155HO	555	1.5	2.3	2.5	5.0	-87	33	3.0	
SP 652077s1; LSR-CTR,mm,T.O.(+),rr,S ₂ ; SP 621103-0; SP 632033s1	SP 6711156HOA	556	2.5	3.5	3.5	5.0	-88	13	2.5	
SP 652048s1; LSR-CTR,mm,T.O.(+),R&r,S ₂ ; SP 621103-0; SP 632067s1	SP 6711157HO	557	1.5	2.5	2.5	5.3	-89	28	2.0	
SP 652062s1; LSR-CTR,mm,T.O.(+),R&r,S ₂ ; SP 621103-0; SP 632095s1	SP 6711158HO	558	2.2	3.7	4.0	5.0	-90	15	2.5	
SP 5481-0 (CT sus. ck.) US 33 US 41	Acc. 2483	559	2.5	3.7	3.8	6.0	-78	77	5.5	
								61	4.0	
								35	2.5	

a/ Field plots on Hospital Farm, Fort Collins, Colorado; inoculation and frequent sprinkling used to promote leaf spot development; plots 2 rows x 20'; randomized block design (+).

b/ Results from Thatcher, Utah(furnished by D.L.Mumford) were based on 2 replications; plots 1 row x 25'; curly top exposure intensified artificially.

c/ Leaf spot grades (B.A. Nelsen): 0 = no leaf spot; 10 = complete defoliation.

d/ Foliage vigor (B.A. Nelsen): larger no. = greater vigor.

e/ Curly top grades (D.L. Mumford): 0 = no symptoms; 9 = dead.

Table 3 --Agronomic and disease resistance evaluation of experimental, LSR-CTR hybrids having FC 901 as the female parent, Fort Collins, Colorado and Thatcher, Utah, 1967(see Exp. 11A for description of the ♂ parents of the hybrids in section I.).

Description <u>a/</u>	: Fort Collins, Colo., Exp. 5A (9-plot averages) <u>b/</u> :Thatcher, Utah <u>c/</u>										
	:Fort Collins:Entry:		: Acre yield :		: Leaf spot <u>d/</u> :		: Plants:		:Curly top		
	: seed no. :	: no. :	: Gross :	: Roots :	: Sucrose:	: 8/27 :	: 9/25 :	: 100' :	: 8/16 :	: 9/25	
			Lbs.		Tons		%		No.		
I. F ₁ Hybrids having FC 901 aa as the ♀ parent.											
FC 901 aa ♀ x SP 652070s1 mm	SP 671151H02	181	3979	12.20	16.33	2.72	3.28	111	42	2.0	
" " " x " 652014s1 "	" 671152H02	182	4760	14.36	16.57	1.56	1.67	109	32	1.5	
" " " x " 652016s1 "	" 671153H02	183	5220	15.69	16.62	2.22	2.44	111	35	2.0	
" " " x " 652017s1 "	" 671154H02	184	4928	15.24	16.18	2.06	2.06	112	23	1.0	
" " " x " 652005s1 "	" 671155H02	185	4589	13.67	16.78	3.17	3.11	113	39	2.0	
" " " x " 652077s1 "	" 671156H02	186	4152	12.91	16.09	3.33	3.22	115	55	2.5	
" " " x " 652048s1 "	" 671157H02	187	4285	12.87	16.64	2.56	2.28	111	20	2.0	
" " " x " 652062s1 "	" 671158H02	188	4236	12.59	16.82	3.39	3.28	111	59	2.5	
II. Checks											
FC(502/2 x 504)mm CMS ♀ x FC 901	SP 641204H03	189	5181	15.40	16.83	2.22	2.39	112			
SL(129 x 133)mm CMS ♀ x SP 6322-0	Acc. 2646	190	4248	12.94	16.42	3.67	3.50	112	41	2.5	
US 33									75	4.0	
US 41									35	2.5	
SP 5481-0 (CT sus. ck.)	Acc. 2483								77	5.5	
General mean											
S. E. of entry mean			4557.73	13.7870	16.5278	2.69	2.72	111.7			
S. E. of entry mean as % of gen. mean			131.33	.3932	.1025	.14	.15	1.66			
L.S.D. (.05)			2.88	2.85	.62	5.30	5.60	1.48			
F			371	1.11	.29	.40	.43	4.69			
			11.46**	10.77**	6.63**	23.10**	17.08**	.74			

a/ Lines are multigerm (MM) except where otherwise indicated. CMS and aa denote cytoplasmic and Mendelian types of male sterility, respectively.

b/ Experiment 5A: plots 1 row x 20'; randomized block design; inoculation and frequent sprinkling used to promote development of leaf spot; curly top exposure negligible.

c/ Results at Thatcher (furnished by D.L. Mumford) were based on 2 replications; plots 1 row x 25'; curly top exposure intensified artificially.

d/ Leaf spot grades (B.A. Nelsen): 0 = no leaf spot; 10 = complete defoliation.

e/ Curly top grades (D.L. Mumford): 0 = no symptoms; 9 = dead.

** F exceeds the 1% point.

Top-cross Tests at Fort Collins, Colorado, and Thatcher, Utah

Top-cross hybrids, involving the parental material described in Table 4, were evaluated in an agronomic test (Exp. 2A) in the leaf spot field at Fort Collins, Colorado, and in an observational test (for curly top resistance) near Thatcher, Utah, in 1967.

Experiment 2A consisted of 1-row, 20-foot plots (rows 20 inches apart), with 8 replications and an equalized-random-block design. An accurately measured section of each plot (usually about 17 feet of row) was harvested for root yield and sucrose determinations. Severe leaf spot exposure was developed with the aid of inoculation and frequent sprinkling.

The test near Thatcher, conducted by D. L. Mumford, involved plots 1 row x 25 feet in size, a minimum of 2 replications, and artificial techniques for intensification of curly top exposure. The resulting curly top epidemic was classed as moderate.

The results of Experiment 2A are presented in Tables 5 through 8. The results of curly top resistance comparisons at Thatcher are summarized in Tables 9 and 10.

On the basis of curly top grades (Table 10), numerous hybrids--particularly among those having FC 901 as the male parent--were at least as high as US 41 in curly top resistance. As expected, hybrids of SP 6322-0 were highest in leaf spot resistance (Table 8). Three hybrids of FC 901 and two of SP 6322-0 were classed as high in resistance to both leaf spot and curly top (leaf spot and curly top grades 3.0 or lower). Of those 5 hybrids, the following were relatively high in gross sucrose yield in Experiment 2A [performance shown in comparison with that of the standard variety, SL(129 x 133) x SP 6322-0]:

Hybrid	Acre yield		Sucrose (%)
	Gross suc.:	Roots	
	(Lb.)	(Tons)	
SP 632028s1-CMS* x FC 901*	4935	15.39	16.02
SP 632090s1-CMS* x SP 6322-0	4926	15.74	15.65
FC 601-CMS* x SP 6322-0	4881	15.44	15.82
SL(129 x 133) x SP 6322-0 (stand. var.)	4119	13.42	15.36
LSD (.05)	447	1.33	0.43

* = Resistant to both leaf spot and curly top

The outstanding hybrids in Experiment 2A, in gross sucrose yield, were those involving a combination of FC 504 and FC 502/2 as the female parent. As shown in Section I of Table 5, the respective hybrids having FC(504 x 502/2) as the female parent were highest in gross sucrose yield among all of the hybrids of the corresponding pollinator lines. The average of all 4 hybrids of FC(504 x 502/2)--i.e. 5289 pounds per acre--exceeded the corresponding average of the nearest competitor by 408 pounds--a highly significant amount. Hybrids of FC(504 x 502/2) were high in sucrose percentage.

Table 4 --Description of parental material involved in top-cross tests at Fort Collins, Colorado (Exp. 2A), Thatcher, Utah, and Hereford, Texas, 1967.

Line no.	No. ^{a/}	gen.	self.	Description and/or source
<u>I. Monogerm, inbred lines, used as females or components of females ^{b/}</u>				
FC 502	1	T.O.; LSR; V.F.S.		715 mm ♀ x US 201 MM
FC 502/2	2	" " ; "		SP 602008s1; subline of FC 502
FC 503	2	" " ; "		derived from V.F.S. 716
FC 504	2	" " ; "		" " " 6-2
FC 505	2	" " ; "		SP 602063s1; US 201 MM x T.O. mm
FC 601	1	" " ; LSR-CTR; SP 622071s1; SP 611101-0		
McF 648-3		" " ; LSR; J. S. McFarlane		
SL 129		" " ; CTR; F. V. Owen		
SL 133		" " ; " ; " " "		
SP 581194s1	1	" " ; LSR; US 201 MM x T.O. mm		
SP 622005s1	2	" " ; " ; SP 602278.; US 201 MM x T.O. mm		
SP 622009s1	2	" " ; " ; " " ; " " " " " "		
SP 622089s1	2	" " ; " ; " 602282.; " " " " " "		
SP 622113s1	2	" " ; " ; " " ; " " " " " "		
SP 632028s1	1	" " ; LSR-CTR; SP 611101-0		
SP 632090s1	1	" " ; " " ; " "		
SP 6423-01		CMS; LSR; G. E. Coe		

II. Pollinators (multigerm):

FC 901	LSR-CTR; prod. of B.C.; US 201 non-recur.parent
McF 663	CTR-bolt. res., from Salinas, Calif.(J.S.McFarlane)
SP 59B18-0	LSR-BRR, from E. Lansing, Mich.(G.J.Hogaboam)
SP 6322-0	LSR-BRR, from Beltsville, Md. (G.E. Coe)

^{a/} Numbers indicate known generations of selfing. Additional selfing may have occurred.

^{b/} Cytoplasmic male sterility was used to enforce all crossing involving the lines listed.

Table 5 .--Results of top-cross test, monogerm hybrids, Fort Collins, Colorado, 1967; Exp. 2A; basic data presented as 8-plot averages.

<u>Gross Sucrose per Acre (Lbs.)</u>						
<u>♀ (mm, LSR)</u>			<u>♂ (MM)</u>			<u>LSD</u>
CMS phase of T.O. lines below:			LSR-BRR	LSR-CTR	CTR-NB	(.05)
Strain no.	Equiv.	SP	SP	FC	McF.	Aver.
	: stage	: 6322-0	: 59B18-0	: 901	: 663	: av. of
						: avs.
<u>I. 1966 Top-cross Hybrids (Fort Collins Production).</u>						
SP 622005s1	B ₁	4542	4772	4547	4627	4622
SP 622009s1	B ₁	4618	4785	5101	5018	4881
SP 622089s1	B ₁	4438	3933	4186	4550	4277
SP 622113s1	B ₁	4056	3968	4193	3839	4014
SP 632028s1*	B ₁			4935		
SP 632090s1*	B ₁	4926	4927	4394	4269	4629
FC 502 x McF. 648-3		4286	4075	4547	4456	4341
FC(504 x 502/2)		5341	5231	5181	5401	5289
FC 601*	B ₂	4881	5047	4083	4437	4612
FC(502/2 x 601*)		4732	4904	4339	4885	4715
FC 505	B ₃	4287	4254	4509	4226	4319
Aver.(excl. SP 632028s1)		4611	4590	4508	4571	141
<u>II. 1966 Top-cross Hybrids (Beltsville Production).</u>						
Acc. 2670[FC(503 x 502/2) x FC 901]				4827		
Acc. 2671[(SP 581194s1 x FC 502/2) x FC 901]				4617		
Acc. 2672[FC(504 x 502/2) x FC 901]				5085		
Acc. 2673[FC(502/2 x 601) x FC 901]				4556		
Acc. 2674[SP 6423-01 x FC 901]				3662		
<u>III. Standards</u>						
Acc. 2646[SL(129 x 133) x SP 6322-0]				4119		
SP 641204H03[FC(502/2 x 504) x FC 901]				5057		
LSD (.05) for 8-plot avs.		447	447	447	447	
LSD (.05) for av. of avs.						224

* = Resistant to curly top as well as to leaf spot.

Table 6 --Results of top-cross test, monogerm hybrids, Fort Collins, Colorado, 1967; Exp. 2A; basic data presented as 8-plot averages.

Roots per Acre (Tons)						
♀(mm, LSR)		♂(MM)				LSD
CMS phase of T.O.lines below		LSR-BRR	LSR-CTR	CTR-NB	:(.05)	
Strain no.		Equiv.	SP	SP	FC	McF.
		: stage	: 6322-0	: 59B18-0	: 901	: 663
I. 1966 Top-cross Hybrids (Fort Collins Production).						
SP 622005s1	B ₁	14.63	15.51	14.33	14.60	14.77
SP 622009s1	B ₁	15.05	15.77	16.14	15.96	15.73
SP 622089s1	B ₁	14.10	12.63	13.37	14.24	13.59
SP 622113s1	B ₁	12.88	12.70	13.37	12.21	12.79
SP 632028s1*	B ₁			15.39		
SP 632090s1*	B ₁	15.74	15.92	14.37	14.06	15.02
FC 502 x McF. 648-3		13.34	12.90	14.02	13.93	13.55
FC (504 x 502/2)		16.59	16.55	16.41	16.95	16.63
FC 601*	B ₂	15.44	16.45	12.93	14.17	14.75
FC (502/2 x 601*)		14.68	15.42	13.35	15.06	14.63
FC 505	B ₃	13.55	13.50	13.95	13.59	13.65
Aver.(excl. SP 632028s1)		14.60	14.74	14.22	14.48	0.42
II. 1966 Top-cross Hybrids (Beltsville Production).						
Acc. 2670[FC(503 x 502/2) x FC 901]				14.59		
Acc. 2671[(SP 581194s1 x FC 502/2)xFC 901]				14.01		
Acc. 2672[FC(504 x 502/2) x FC 901]				15.78		
Acc. 2673[FC(502/2 x 601) x FC 901]				13.99		
Acc. 2674[SP 6423-01 x FC 901]				11.94		
III. Standards						
Acc. 2646[SL(129 x 133) x SP 6322-0]				13.42		
SP 641204HO3[FC(502/2 x 504) x FC 901]				16.01		
LSD (.05) for 8-plot avs.		1.33	1.33	1.33	1.33	
LSD (.05) for av. of avs.						0.66

* = Resistant to curly top as well as to leaf spot.

Table 7 --Results of top-cross test, monogerm hybrids, Fort Collins, Colorado, 1967; Exp. 2A; basic data presented as 8-plot averages.

Sucrose Percentage

♀(mm, LSR)		♂(MM)				LSD
GMS phase of T.O. lines below:		LSR-BRR	LSR-CTR	CTR-NB		(.05)
Strain no.	: Equiv. : : stage :	SP : 6322-0:	SP : 59B18-0:	FC : 901 :	McF. : 663 :	Aver. : :av.of :avs.

I. 1966 Top-cross Hybrids (Fort Collins Production).

SP 622005s1	B ₁	15.51	15.34	15.88	15.84	15.64
SP 622009s1	B ₁	15.34	15.16	15.80	15.72	15.51
SP 622089s1	B ₁	15.73	15.59	15.64	15.98	15.74
SP 622113s1	B ₁	15.72	15.60	15.68	15.71	15.68
SP 632028s1*	B ₁			16.02		
SP 632090s1*	B ₁	15.65	15.47	15.32	15.19	15.41
FC 502 x McF. 648-3		16.05	15.77	16.23	15.94	16.00
FC(504 x 502/2)		16.09	15.81	15.82	15.95	15.92
FC 601*	B ₂	15.82	15.36	15.79	15.66	15.66
FC (502/2 x 601*)		16.12	15.89	16.24	16.21	16.12
FC 505	B ₃	15.83	15.77	16.16	15.59	15.84
Aver.(excl. SP 632028s1)		15.79	15.58	15.86	15.78	0.14

II. 1966 Top-cross Hybrids (Beltsville Production).

Acc. 2670[FC(503 x 502/2) x FC 901]	16.56
Acc. 2671[(SP 581194s1 x FC 502/2)xFC 901]	16.49
Acc. 2672[FC(504 x 502/2) x FC 901]	16.08
Acc. 2673[FC(502/2 x 601) x FC 901]	16.28
Acc. 2674[SP 6423-01 x FC 901]	15.34

III. Standards

Acc. 2646[SL(129 x 133) x SP 6322-0]	15.36
SP 641204H03[FC(502/2 x 504) x FC 901]	15.75

LSD (.05) for 8-plot avs.	0.43	0.43	0.43	0.43	
LSD (.05) for av. of avs.					0.22

* = Resistant to curly top as well as to leaf spot.

Table 8 .--Results of top-cross test, monogerm hybrids, Fort Collins, Colorado, 1967; Exp. 2A; basic data presented as 8-plot averages.

<u>Leaf Spot Grade</u> ^{a/}						
<u>♀(mm, LSR)</u>			<u>♂(MM)</u>			<u>:LSD</u>
CMS phase of T.O. lines below:			LSR-BRR	LSR-CTR	CTR-NB	: (.05)
Strain no.			: Equiv. : SP : SP	: FC	: McF.	: Aver. : for
			: stage : 6322-0:59B18-0:	901	: 663	: : av. of
						: : avs.
<u>I. 1966 Top-cross Hybrids (Fort Collins Production).</u>						
SP 622005s1	B ₁	3.0	3.3	3.4	3.9	3.4
SP 622009s1	B ₁	2.9	2.9	2.8	3.7	3.1
SP 622089s1	B ₁	2.6	3.3	3.4	3.7	3.3
SP 622113s1	B ₁	2.8	3.4	3.3	3.8	3.3
SP 632028s1*	B ₁			2.7		
SP 632090s1*	B ₁	2.4	2.9	3.3	4.1	3.2
FC 502 x McF. 648-3		2.8	3.4	2.8	3.4	3.1
FC(504 x 502/2)		1.8	2.3	2.6	2.8	2.4
FC 601*	B ₂	2.1	2.3	2.5	3.3	2.6
FC(502/2 x 601*)		1.5	2.3	2.8	2.6	2.3
FC 505	B ₃	2.9	3.3	3.3	4.1	3.4
Aver.(excl. SP 632028s1)		2.5	2.9	3.0	3.5	0.14
<u>II. 1966 Top-cross Hybrids (Beltsville Production).</u>						
Acc. 2670[FC(503 x 502/2) x FC 901]				2.6		
Acc. 2671[(SP581194s1 x FC 502/2)xFC 901]				3.3		
Acc. 2672[FC(504 x 502/2) x FC 901]				2.8		
Acc. 2673[FC(502/2 x 601) x FC 901]				2.5		
Acc. 2674[SP 6423-01 x FC 901]				3.9		
<u>III. Standards</u>						
Acc. 2646[SL(129 x 133) x SP 6322-0]				4.2		
SP 641204H03[FC(502/2 x 504) x FC 901]				2.9		
LSD (.05) for 8-plot avs.		0.44	0.44	0.44	0.44	
LSD (.05) for av. of avs.						0.22

^{a/} Leaf spot grades (B. A. Nelsen, 8/28/67): 0 = no leaf spot; 10 = complete defoliation.

* = Resistant to curly top as well as to leaf spot.

Table 9 .--Curly top resistance comparisons, LSR-CTR, monogerm (top-cross) hybrids, Thatcher, Utah, 1967, by D. L. Mumford; basic results, as presented, are averages of a minimum of 2 plots, 1 row x 25' in size.

Curly Top Percentage

♀ (mm, LSR)			♂ (MM)			
CMS phase of T.O. lines below			LSR-BRR	LSR-CTR	CTR-NB	Aver.
Strain no.			SP	SP	FC	McF. & McF.
			: stage	: 6322-0 : 59B18-0:	: 901	: 663 : 663

I. 1966 Top-cross Hybrids (Fort Collins Production) ^{a/}

SP 622005s1	B ₁			32	68	50
SP 622009s1	B ₁			62	62	62
SP 622089s1	B ₁			48	79	64
SP 622113s1	B ₁			62	60	61
SP 632028s1*	B ₁			47		
SP 632090s1*	B ₁	49	46	59	64	62
FC 502 x McF. 648-3				76	68	72
FC(504 x 502/2)				69	84	77
FC 601*	B ₂	56	57	38	51	45
FC(502/2 x 601*)		42	47	45	63	54
FC 505	B ₃			52	58	55
Aver. (excl. SP 632028s1)				54	66	60

II. Standards

Acc. 2483 (SP 5481-0)	77
US 33	68
US 41	44

^{a/} These hybrids also occurred in Fort Collins Exp. No. 2A, 1967.

* = Resistant to curly top as well as to leaf spot.

Table 10.--Curly top resistance comparisons, LSR-CTR, monogerm (top-cross) hybrids, Thatcher, Utah, 1967, by D. L. Mumford; basic results, as presented, are averages of a minimum of 2 plots, 1 row x 25' in size.

<u>Curly Top Grade</u> ^{a/}							
<u>♀(mm, LSR)</u>				<u>♂(MM)</u>			
CMS phase of T.O. lines below				LSR-BRR	LSR-CTR	CTR-NB	Aver.
Strain no.				SP	SP	FC	McF. & McF.
: stage				: 6322-0	: 59B18-0	: 901	: 663 : 663
<u>I. 1966 Top-cross Hybrids (Fort Collins Production)</u> ^{b/}							
SP 622005s1	B ₁					3.5	4.5 4.0
SP 622009s1	B ₁					4.0	4.5 4.3
SP 622089s1	B ₁					3.0	4.5 3.8
SP 622113s1	B ₁					4.0	4.0 4.0
SP 632028s1*	B ₁					3.0	
SP 632090s1*	B ₁	3.0	3.5			3.0	3.5 3.3
FC 502 x McF. 648-3						3.5	4.5 4.0
FC(504 x 502/2)						3.5	4.0 3.8
FC 601*	B ₂	3.0	4.0			2.0	3.5 2.8
FC(502/2 x 601*)		3.5	4.0			3.0	3.5 3.3
FC 505	B ₃					3.5	4.0 3.8
Aver.(excl. SP 632028s1)						3.3	4.1 3.7
<u>II. Standards</u>							
Acc. 2483 (SP 5481-0)						5.5	
US 33						4.0	
US 41						3.0	

^{a/} Basis of grades: 0 = no symptoms; 9 = dead.

^{b/} These hybrids also occurred in Fort Collins Experiment No. 2A, 1967.

* = Resistant to curly top as well as to leaf spot.

Cooperator's Test of Top-cross Hybrids at Hereford, Texas

Nine top-cross hybrids and one standard variety, occurring in Experiment 2A at Fort Collins, Colorado, also were evaluated by the staff of the Holly Sugar Corporation at Hereford, Texas. The test at Hereford consisted of 1-row plots, 28 feet long (rows 30 inches apart), in a randomized-block arrangement with 9 replications. The crop was planted on March 20 and harvested on October 28. A 25-foot section in each plot was harvested for root yield. Two 10-beet samples from each plot were analyzed for sucrose percentage.

The field was treated, pre-planting, with Thimet for curly top control. Repeated applications of Kocide were made for leaf spot control. The resulting exposures to curly top and leaf spot were negligible and mild, respectively. Stand, vigor, and general health of the crop were quite satisfactory. Reliability of the test was considered very good.

For convenience in studying the harvest results from the Hereford test, they were converted to percent of the standard variety, SL(129 x 133) x SP 6322-0, and the percentages are shown in Table 11, together with comparable results extracted from the report for Fort Collins Experiment No. 2A. Actual leaf spot grades also are shown in the table.

The performance of FC(502/2 x 601) x McF. 663 is of special interest in that: (1) it significantly exceeded the best of the local checks in gross sucrose yield and sucrose percentage at Hereford; and (2) it significantly exceeded the standard variety [SL(129 x 133) x SP 6322-0] in yield of roots and gross sucrose and in sucrose percentage at Fort Collins. Averages of the two locations showed that FC(502/2 x 601) x McF. 663 was significantly above the standard variety both in gross sucrose yield and in sucrose percentage. The hybrid, SP 632028sl x FC 901, also was attractive in both gross sucrose yield and sucrose percentage. Averages of the two locations showed that it was significantly above the standard variety in sucrose percentage and nearly so in gross sucrose yield.

Table 11.--Summary of results for LSR-CTR, monogerm, top-cross hybrids at Fort Collins, Colorado (Exp. 2A) and Hereford, Texas, in 1967; harvest results expressed as percent of the standard variety, SL(129 x 133) x SP 6322-0.

Description <u>a/</u>	Fort Collins		Gross suc. yield		Root yield		Sucrose percent		Leaf spot <u>b/</u>	
	seed no.	F.C.:Her.: Aver.	F.C.:Her.: Aver.	F.C.:Her.: Aver.	F.C.:Her.: Aver.	F.C.:Her.: Aver.	F.C.:Her.: Aver.	F.C.:Her.: Aver.	F.C.:Her.: Aver.	F.C.:Her.: Aver.
	No. of reps:	8 : 9 :	8 : 9 :	8 : 9 :	8 : 9 :	8 : 9 :	8 : 9 :	8 : 9 :	8 : 9 :	8 : 9 :
	LSD (.05)	:11 : 9 :	:10 : 8 :	:10 : 8 :	:10 : 8 :	:10 : 8 :	:10 : 8 :	:10 : 8 :	:10 : 8 :	:10 : 8 :
SL(129 x 133)	Acc. 2646	100	100	100.0	100	100	100	100.0	4.2	1.7
x SP 6322-0										
SP 632028s1 x	SP 661203H05	120	98	109.0	115	94	104	104.5	2.7	1.2
FC 901										
SP 632090s1 x	SP 661203H06	107	89	98.0	107	89	100	100.0	3.3	1.3
FC 901										
FC(502/2 x 601)	SP 661203H010	105	103	104.0	99	95	106	107.0	2.8	1.0
x FC 901										
(SP 581194s1 x FC 502/2)	Acc. 2671	112	101	106.5	104	93	107	108.0	3.3	1.0
x FC 901										
SP 6423-01 x	Acc. 2674	89	102	95.5	89	102	100	100.0	3.9	1.3
FC 901										
SP 632090s1 x	SP 661204H06	104	98	101.0	105	95	99	101.0	4.1	1.4
Mcf. 663										
(FC 502 x McF.648-3)	SP 661204H07	108	102	105.0	104	100	104	103.5	3.4	1.0
x McF. 663										
FC 601 x	SP 661204H09	108	93	100.5	106	94	102	101.0	3.3	1.0
Mcf. 663										
FC(502/2 x 601) x	SP 661204H010	119	105	112.0	112	99	106	106.5	2.6	1.0
Mcf. 663										
HH 10(Holly loc.ck.)		95			97		98		2.6	
5224-013(Holly loc.ck.)		92			95		98		2.4	

a/ Cytoplasmic male sterility was used to enforce hybridization.

b/ Basis of leaf spot grades: 0 = no leaf spot; 10 = complete defoliation. Grade determinations were made at Fort Collins by B. A. Nelsen; at Hereford by J. O. Gaskill.

c/ Leaf spot was partially controlled at Hereford by repeated spray applications of Kocide.

Identification of Superior Genotypes in FC 901

In 1966, a series of reciprocal top crosses were made for the purpose of preliminary evaluation of the combining ability of 21 individual mother beets of FC 901. Open-topped, polyethylene chambers in the greenhouse were used as isolators. Each chamber contained one male-fertile plant of FC 901, in a slightly elevated position, and 2 or 3 (usually 3) plants of each of the following monogerm, CMS, F_1 hybrids:

<u>Code or root no.</u>	<u>Description</u>
767	FC(504 x 502/2)
772	FC(502/2 x 601)

Seed produced by each F_1 hybrid in each chamber, insofar as available (total of 41 seed lots), was planted in the leaf spot field at Fort Collins (Exp. 3A) and near Thatcher, Utah, in 1967. In addition, seed produced by the respective plants of FC 901 was planted in the Fort Collins leaf spot field (Exp. 10A). Experiment 3A consisted of plots 1 row (20 inches) x 20 feet in size, with 7 replications and an equalized-random-block design. An accurately measured section of each plot (usually about 17 feet of row) was harvested for root yield and sucrose determinations. Severe leaf spot exposure was developed with the aid of inoculation and frequent sprinkling. Essential details regarding the design of Experiment 10A and the test at Thatcher are given in Tables 14 and 13, respectively.

The summarized results for the 3 experiments named in the preceding paragraph are presented in Tables 12, 13, and 14. The LSD values and the significant differences shown by asterisks (*) (Table 12) were based on variance analyses of results for all entries in the test. A separate analysis of variance was performed for gross sucrose yield, omitting the hybrid of male root no. 732-23 and the standard check variety, SL(129 x 133) x SP 6322-0. F tests in this analysis showed that highly significant differences occurred between males; also that the interaction, males x females, was highly significant.

Three male roots (732-18, 732-29, 732-48) were outstanding. Each of the two hybrids of each of those roots (total of six hybrids) was significantly above the corresponding general hybrid average in gross sucrose yield (Table 12). Each of the six hybrids also was above the corresponding general hybrid average in sucrose percentage. As shown in Table 13, these hybrids were relatively high in resistance to leaf spot and curly top. Work currently is under way to combine and utilize the selfed progenies of roots 732-18, 732-29, and 732-48.

Table 12.--Harvest results of reciprocal top-cross test, Fort Collins, Colorado, 1967; basic data presented as 7-plot averages (Exp. no. 3A).

♂		♀		
Root no.	Code no. (6611__)	Gross sucrose yield (lb.) : 767 : 772 : Average :	Root yield (tons) : 767 : 772 : Average :	Sucrose % : 767 : 772 : Average :
732-29	57	5651* 5570* 5611* 5859* 4674 5081	16.73 16.37* 16.55* 16.89* 17.01* 16.95*	16.69 16.54 16.62
732-48	58	5757* 5960* 4864 4863 5841* 5327	17.28* 18.01* 17.65* 16.69 16.54 16.62	16.36 16.29 16.33
731-8	59	4864 4484 4863 5081 5841* 5327	14.88 13.76 14.32 15.00 15.45 16.68	16.20 16.44
732-2	60	5298 4863 5081 5841* 5327	15.90 15.00 15.45 16.68 17.01* 17.00*	16.20 16.44
732-36	61	5841* 4813 5327	17.18* 14.15 15.67	17.01* 17.00*
732-5	62	5302 4514 4908	15.96 13.82 14.89	16.31 16.46
732-9	63	4714 4502 4608	14.91 14.29 14.60	15.75 15.78
732-30	64	5618 4663 5141	16.79 14.10 15.45	16.53 16.64
732-17	65	5801* 5093 5447*	17.60* 15.66 16.63*	16.29 16.39
732-39	66	5148 4902 5025	15.87 14.90 15.39	16.45 16.35
732-25	67	4687 5213 4950	14.06 15.27 14.67	16.64 17.08* 16.86*
732-10	68	5043 4628 4836	15.04 13.92 14.48	16.62 16.69
731-3	69	5349 5239 5294	16.08 16.59* 16.34*	15.92 16.28
732-45	70	4869 4683 4776	14.56 14.32 14.44	16.34 16.53
732-23	71	4913 4934	14.63 14.96	16.78* 16.48
732-35	72	5390 4477 4934	16.30 13.62 14.96	16.52 16.44
732-22	73	4942 4727 4835	15.68 14.63 15.16	15.76 16.16 15.96
732-13	74	5045 5076 5061	15.13 15.22 15.18	16.68 16.66 16.67
732-6	75	4916 4091 4504	14.57 12.69 13.63	16.86 16.10 16.48
732-18	76	5746* 5262* 5504*	17.16* 15.85 16.51*	16.76 16.60 16.68
731-11	81	5496 4779 5138	16.72 14.58 15.65	16.44 16.39 16.42
Gen'l. Hyb. average (exclude code 71)		5274 4877 5076	15.92 14.84 15.38	16.56 16.43 16.50
Ck.[SL(129 x 133) x SP 6322-0]	4571		14.35	15.96
LSD-1 ^{a/}	364	364	1.11	1.11
LSD-2 ^{b/}		258		0.79
LSD-3 ^{c/}	112		0.34	0.10

^{a/} LSD-1 = LSD (.05) for comparing individual hybrids with the appropriate general hybrid average.

^{b/} LSD-2 = LSD (.05) for comparing averages for males (♂) with appropriate general hybrid average.

^{c/} LSD-3 = LSD (.05) for comparing general hybrid averages for females (♀).

* = Average exceeds the appropriate general hybrid average by an amount at least equal to LSD (.05).

Table 13.--Disease reaction of reciprocal top-cross hybrids, Fort Collins, Colorado (Exp. 3A), and Thatcher, Utah, 1967.^{a/}

Root no.	♂ Code no. (6611__)	♀								
		Leaf spot grade ^{b/}			Curly top % ^{c/}			Curly top grade ^{c/}		
		(8/28), Fort Collins			(8/16), Thatcher			(9/25), Thatcher		
		767	772	Average	767	772	Average	767	772	Average
732-29	57	2.07	1.71	1.89	57	39	48	2.5	2.5	2.5
732-48	58	2.00	1.43	1.72	67	44	56	3.0	2.0	2.5
731-8	59	3.00	3.29	3.15	47	36	42	3.0	2.5	2.8
732-2	60	1.50	2.29	1.90	84	51	68	3.5	3.0	3.3
732-36	61	2.29	2.64	2.47	70	27	49	2.5	2.0	2.3
732-5	62	2.29	2.36	2.33	38	49	44	3.0	2.0	2.5
732-9	63	3.50	3.21	3.36	70	16	43	3.0	2.0	2.5
732-30	64	2.21	2.36	2.29	47	38	43	2.5	2.0	2.3
732-17	65	2.64	2.86	2.75	78	44	61	4.5	2.5	3.5
732-39	66	2.86	2.57	2.72	69	24	47	3.5	2.0	2.8
732-25	67	2.21	1.57	1.89	65	19	42	2.5	1.5	2.0
732-10	68	2.50	2.07	2.29	70	31	51	4.0	2.5	3.3
731-3	69	2.79	2.57	2.68	52	34	43	3.5	1.5	2.5
732-45	70	2.36	2.14	2.25	69	20	45	4.0	2.0	3.0
732-23	71		1.71			37			2.5	
732-35	72	2.86	3.71	3.29	68	36	52	3.5	2.5	3.0
732-22	73	3.07	3.36	3.22	41	38	40	3.0	2.0	2.5
732-13	74	2.86	2.86	2.86	90	45	68	4.0	2.0	3.0
732-6	75	2.29	3.07	2.68	69	62	66	3.0	3.0	3.0
732-18	76	2.07	2.57	2.32	38	46	42	2.5	2.5	2.5
731-11	81	2.64	2.36	2.50	53	29	41	3.0	2.5	2.8
Gen'l. hyb. average (exclude code 71)		2.50	2.55	2.53 ^{d/}	62	36	50	3.2	2.2	2.7
Check [SL(129 x 133) x SP 6322-0]		3.86								
Check (SP 6051-0)						44				
Check (US 33)						55				
Check (US 41)						34				
Check (SP 5481-0)						77				

^{a/} Experiment 3A, at Fort Collins, consisted of plots 1 row x 20' in size with 7 replications. At Thatcher, plots were 1 row x 25' in size, and there were 2 replications, except for US 33 and US 41 which occurred in 4 plots each.

^{b/} Leaf spot grades (B. A. Nelsen): 0 = no leaf spot; 10 = complete defoliation.

^{c/} Curly top data were furnished by D. L. Mumford. Basis of curly top grades: 0 = no symptoms; 9 = dead.

^{d/} LSD (.05) for comparison of the indicated general hybrid average with averages for males (♂) = 0.30.

Evaluation of S₁ Lines Derived from GW 359

Most of the LSR-CTR lines developed at Fort Collins, with assistance of the Logan, Utah, and Salinas, California, Stations, are direct or indirect products of one or more generations of backcrossing in which CTR material served as the recurrent parental type. Since heterogeneity of CTR material, as a class, presumably is rather low, it seems advisable to broaden the genetic base of current LSR-CTR lines by crossing them with relatively unrelated material. Outcrosses of this sort have been made at Fort Collins during the last several years. The evaluation of the S₁ lines described below represents one step toward the production of another series of such outcrosses.

In 1965, 180 S₁ lines, resulting directly from bag-selfing (by LeRoy Powers) of plants of GW 359, were compared for leaf spot resistance in non-replicated plots on the Hospital Farm. The same lines also were compared for root size and sucrose percentage, by R. J. Hecker, on the Agronomy Research Center at Fort Collins. The 12 most attractive lines (with major emphasis on leaf spot resistance and with some consideration of sucrose percentage and other characters) were brought to seed in separate, isolated groups in 1966.

The 12 seed increases obtained in 1966 were compared in Experiment 4A on the Hospital Farm in 1967. Plots were 1 row (20 inches) x 20 feet in size, with 7 replications, and a randomized-block design. The usual harvest procedure was followed (see Exp. 2A and 3A). The results of Experiment 4A are presented in Table 15.

Since all of the lines are products of only one generation of selfing (in "self-sterile type", broad-base material), and since they differed considerably in productivity and sucrose percentage in Experiment 4A, it is assumed that the use of the best lines in crosses with LSR-CTR material will open the way for the development of superior LSR-CTR lines--i.e. superior in combining ability for productivity and sucrose percentage. Such crosses currently are being made in the greenhouse. Subsequent steps, of course, must include the production of a segregating generation and selection for curly top resistance, among others.

Table 15.--Comparison of LSR, multigerm, S₁ lines derived from GW 359, Fort Collins, Colorado, 1967 (Exp. 4A, 7-plot averages).

Immediate parent (i.e. the S ₁ generation--L.R.P.):	Fort Collins: seed no.	Entry: no.	Acre yield		Sucrose:	Leaf spot		Vigor		Plants per 100'
			Gross	Roots		8/27	9/11	8/11		
			Lbs.	Tons		%	No.			
64-9239-358	SP 661005-0	161	3021	9.79	15.36	3.8	2.9	5.6	114	
" -48	" 661006-0	162	4034	11.68	17.25	2.1	1.8	5.7	119	
" -346	" 661007-0	163	2714	8.05	16.89	2.1	2.3	4.7	123	
" -414	" 661008-0	164	3598	11.03	16.34	2.1	1.9	4.9	120	
" -34	" 661009-0	165	4594	14.98	15.37	2.9	2.6	7.0	118	
" -413	" 661010-0	166	4719	14.25	16.57	2.3	2.1	6.3	120	
" -138	" 661011-0	167	4929	15.05	16.39	2.3	2.3	6.7	119	
" -65	" 661012-0	168	3014	9.63	15.64	2.4	2.0	5.9	119	
" -25	" 661013-0	169	5022	14.76	16.97	1.9	1.5	6.3	117	
" -337	" 661014-0	170	3966	12.50	15.85	4.0	3.1	5.7	122	
" -31	" 661015-0	171	3409	10.98	15.56	3.2	2.4	5.9	123	
" -377	" 661226-0	172	5304	17.08	15.54	2.9	2.6	6.9	116	
General mean			4026.90	12.4822	16.1452	2.67	2.27	5.95	119.18	
S. E. of entry mean			209.36	.6537	.1514	.14	.16	.16	3.19	
S. E. of entry mean as % of gen. mean			5.20	5.24	.94	5.39	6.99	2.68	2.68	
L.S.D. (.05)			592	1.85	.43	.41	.45	.45	9.04	
F			17.77**	17.50**	19.82**	23.54**	8.56**	20.50**	.77	

a/ Leaf spot (B. A. Nelsen): 0 = no leaf spot; 10 = complete defoliation.

b/ Foliage vigor (B. A. Nelsen): Larger no. = greater vigor.

** F exceeds the 1% point.

Cooperative Evaluation Tests of LSR-CTR Varieties

Seed supplies of the varieties listed in Table 16 were assembled at Fort Collins and distributed to cooperators for evaluation. A test at Tracy, California, was not harvested in time to be included in this report. The results of all other tests are presented as follows:

State :	Locality :	Agency conducting test :	Table :	Fig.
<u>I. Agronomic tests, eastern area:</u>				
Iowa	Kanawha	Amer. Crystal Sugar Co.	21	a & b
"	Mason City	" " " "	22	" " "
Md.	Beltsville	U.S. Dept. of Agr.	23	" " "
Minn.	E. Gr. Forks	Amer. Crystal Sugar Co.	24	" " "
<u>II. Agronomic tests, western area:</u>				
Calif.	Hamilton City	Holly Sugar Corp.	25	" " "
Colo.	Fort Collins	U.S. Dept. of Agr.	26	" " "
"	Rocky Ford	Amer. Crystal Sugar Co.	27	" " "
"	Two Buttes	" " " "	28	" " "
Kan.	Lakin	" " " "	29	" " "
"	Tribune	Kan. Agr. Exp. Sta.	30	" " "
Texas	Hereford	Holly Sugar Corp.	31	" " "
<u>III. Observational tests, for evaluation of disease resistance, only:</u>				
Calif.	S. J. Valley	Spreckels Sugar Co.	20	
Iowa	Mason City	Amer. Crystal Sugar Co.	20	
Utah	Thatcher	U.S. Dept. of Agr.	20	
<u>IV. Herbicide resistance comparisons:</u>				
Colo.	Fort Collins	U.S. Dept. of Agr.	32	a & b

General summaries of results for all of the agronomic and disease resistance tests are presented in Tables 17 through 20.

With reference to the agronomic tests, leaf spot was an important factor in 3 tests (Beltsville, Md., Hamilton City, Calif., and Fort Collins, Colo.); Aphanomyces-type black root in one test (Kanawha, Iowa); Rhizoctonia root rot in one test (Beltsville, Md.); and curly

top in none. In this connection it should be noted that chemical control measures were employed for curly top at Hereford, Texas, and for leaf spot at Hereford and at Two Buttes, Colorado. Disease intensification measures were used in the following agronomic tests: For leaf spot, at Beltsville and Fort Collins; and for Aphanomyces, at Kanawha.

The agronomic tests in 1967 were unusually reliable, as a class. An exception was the test at Kanawha, Iowa, where Aphanomyces caused very erratic variations in stand. Another exception was the test at Beltsville, Maryland, where Rhizoctonia caused considerable variation in stand.

One of the high lights of the 1967 results is the high gross sucrose yield of the standard variety, SL(129 x 133) x SP 6322-0 (entry 1), in the eastern area. In the western area, entries 3, 5, and 6 were high in gross sucrose yield. In sucrose percentage, in the western area, entry 3 was disappointing, entry 6 was slightly above the standard variety, and entry 5 was definitely superior. Entry 4 was highest in sucrose percentage in both areas, but it was rather low in root yield.

The relative over-all performance of entry 5 [FC(504 x 502/2) x FC 901] and entry 1 [SL(129 x 133) x SP 6322-0] in 1967 was similar to the relative performance of equivalent varieties in the 1965 test series (1). In that year, FC(502/2 x 504) x FC 901 occurred as entry 5, and SL (129 x 133) x SP 6322-0 occurred as entry 3. In each of the 2 years, based on all tests, the "FC" hybrid was slightly higher in gross sucrose yield, slightly lower in root yield, and substantially higher (2.6 to 2.7%) in sucrose percentage.

The superior gross sucrose yield and acceptable sucrose percentage, shown for entry 6 [FC(504 x 502/2) x McF. 663] in the western area in the 1967 tests, is of special interest since entries 5 and 6 differed only in their male parents--i.e. FC 901 and McF. 663, respectively.

Literature Cited

- (1) Gaskill, J. O., C. L. Schneider, A. M. Murphy, and G. E. Coe. 1966. Development and evaluation of sugarbeet breeding material and varieties carrying resistance to leaf spot and curly top, 1965. Sugarbeet Research, 1965 Rpt., U.S.D.A.-A.R.S., CR-4-66, pp. 173-229.
- (2) Gaskill, J. O., C. L. Schneider, A. M. Murphy, and G. E. Coe. Development and evaluation of sugarbeet breeding material and varieties carrying resistance to leaf spot and curly top, 1966. Sugarbeet Research, 1966 Rpt., U.S.D.A.-A.R.S., Crops Research Division. In Press.

Table 16.--Description of material in cooperative agronomic evaluation tests of LSR-CTR varieties, 1967 a/.

Entry:Fort Collins:		Description and supplier <u>b/</u>
no. :	seed no. :	
1	Acc. 2646	SL(129 x 133)CMS x SP 6322-0; monogerm; LSR-CTR-BRR; Farmers and Manufacturers Beet Sugar Association.
2	Acc. 2675	SP 65209-03 (Coe) CMS x FC 901; monogerm; LSR-CTR; U.S.D.A., Beltsville, Maryland.
3	Acc. 2676	SP 65406-01 (Coe) CMS x FC 901; monogerm; LSR-CTR; U.S.D.A., Beltsville, Maryland.
4	SP 661203H07	(FC 502 x McF. 648-3) CMS x FC 901; monogerm; LSR-CTR; U.S.D.A., Fort Collins, Colorado.
5	Acc. 2672	FC(504 x 502/2) CMS x FC 901; monogerm; LSR-CTR; U.S.D.A., Beltsville, Maryland.
6	SP 661204H08	FC(504 x 502/2) CMS x McF. 663; monogerm; LSR-CTR; U.S.D.A., Fort Collins, Colorado.
7	Acc. 2644	SP 5822-0 (LSR check); multigerm; LSR-BRR; F & M and West Coast Beet Seed Company.
8	Acc. 2645	US H7 (CTR check); monogerm; CTR and bolting resistant; U.S.D.A., Salinas, California.

a/ One local check, furnished by the cooperator, was included in most tests in addition to the varieties listed in this table.

b/ Disease resistance, though varying widely in degree, is indicated by symbols, above, as follows (preplanting classification): BRR = black root resistant (i.e. resistant to the Aphanomyces type black root); CTR = curly top resistant; LSR = leaf spot resistant.

Table 17.--General summary of harvest results, cooperative agronomic evaluation tests of LSR-CTR varieties, 1967; as percent of the standard variety, SL(129 x 133) x SP 6322-0.

Gross Sucrose Yield													
Location	: Diseases <u>a/</u> : No. :		Entry no.								: Loc. <u>b/</u> : LSD <u>c/</u> :		
	: BR : CT : LS : Rh : reps :	1	2	3	4	5	6	7	8	: check : (.05)			
<u>Eastern area:</u>													
(1) Kanawha, Iowa	2-3	1	8	100	87	84	95	88	90	73	84	84	26
(2) Mason City, Iowa		1	9	100	86	94	92	83	93	73	85	89	12
(3) Beltsville, Md.	1	3	2	3	100	93	95	93	93	104	50	115	19
(4) E. G. F., Minn.			9	100	94	89	83	89	96	74	89	85	7
Aver., eastern area				100.0	90.0	90.5	90.8	88.3	95.8	81.3	77.0	93.3	
<u>Western area:</u>													
(5) Ham.City, Calif.	3	9		100	109	125	112	120	118	81	100	110	13
(6) Ft. Col., Colo.	3	9		100	94	117	106	115	119	88	96	99	5
(7) Roc.Ford, Colo.	1	9		100	90	91	86	97	98	87	72	86	8
(8) Two Buttes, Colo.	1-*	8		100	98	110	99	98	106	89	102		8
(9) Lakin, Kansas	1	8		100	99	114	102	108	115	104	102		9
(10) Tribune, Kansas	1-	5		100	101	127	100	113	107	116	106	101	13
(11) Hereford, Texas	*	1*	9	100	90	108	110	112	118	93	98	94	10
Aver., western area				100.0	97.3	113.1	102.1	109.0	111.6	94.0	96.6		
General aver., all locations				100.0	94.6	104.9	98.0	101.5	105.8	89.4	89.5		

a/ Disease exposure: BR = black root (Aphanomyces cochlloides); CT = curly top (virus); LS = leaf spot (Cercospora beticola); Rh = Rhizoctonia root or crown rot; l = mild; 2 = moderate; 3 = severe. No numerical entry for a disease indicates negligible effects, if any. * = Chemical control measures applied.

b/ Local checks were as follows (location numbers in parentheses): (1) Am #3 Hybrid "A"; (2) Am #3 Hybrid "A"; (3) SP 643465-1 x SP 6322-0; (4) Am #3 Hybrid "A"; (5) HH 9; (6) GW 674-56C; (7) Am #2 Hybrid "A"; (10) National com. var. of 1966; (11) Holly no. 5224-013.

c/ LSD (.05) expressed as percent of the gross sucrose yield of the standard variety.

Table 18.--General summary of harvest results, cooperative agronomic evaluation tests of LSR-CTR varieties, 1967; as percent of the standard variety, SL(129 x 133) x SP 6322-0.

Location	Diseases <u>a/</u> :No. :		Entry no.								<u>b/</u> :LSD <u>c/</u>	
	:BR :CT:LS :Rh:reps:	1	2	3	4	5	6	7	8	:check :	(.05)	
<u>Eastern area:</u>												
(1) Kanawha, Iowa	2-3	1	8	100	87	86	88	81	84	73	80	82
(2) Mason City, Iowa		1	9	100	89	101	91	83	94	77	90	89
(3) Beltsville, Md.	1	3	2	3	100	100	108	89	96	108	68	113
(4) E. G. F., Minn.			9	100	95	93	85	89	95	78	89	86
Aver., eastern area				100.0	92.8	97.0	88.3	87.3	95.3	81.5	81.8	92.5
<u>Western area:</u>												
(5) Ham. City, Calif.	3	9	100	108	132	113	118	118	123	81	110	122
(6) Ft. Col., Colo.	3	9	100	93	116	101	109	109	114	89	97	101
(7) Roc.Ford, Colo.	1	9	100	90	98	84	94	94	97	88	81	86
(8) Two Buttes, Colo.	1-*	8	100	97	114	94	96	96	104	91	102	7
(9) Lakin, Kansas	1	8	100	98	119	98	105	105	113	104	99	9
(10) Tribune, Kansas	1-	5	100	106	132	97	112	112	108	117	113	101
(11) Hereford, Texas	*	1*	9	100	96	116	99	107	115	99	102	97
Aver., western area				100.0	98.3	118.1	98.0	105.9	110.6	95.6	100.6	
General aver., all locations				100.0	96.3	110.5	94.5	99.1	105.0	90.5	93.7	

a/ Disease exposure: BR = black root (Aphanomyces cochlidioides); CT = curly top (virus); LS = leaf spot (Cercospora beticola); Rh = Rhizoctonia root or crown rot; 1 = mild; 2 = moderate; 3 = severe. No numerical entry for a disease indicates negligible effects, if any. * = Chemical control measures applied.

b/ Local checks were as follows (location numbers in parentheses): (1) Am #3 Hybrid "A"; (2) Am #3 Hybrid "A"; (3) SP 643465-1 x SP 6322-0; (4) Am #3 Hybrid "A"; (5) HH 9; (6) GW 674-56C; (7) Am #2 Hybrid "A"; (10) National com. var. of 1966; (11) Holly no. 5224-013.

c/ LSD (.05) expressed as percent of the root yield of the standard variety.

Table 19.--General summary of harvest results, cooperative agronomic evaluation tests of LSR-CTR varieties, 1967; as percent of the standard variety, SL(129 x 133) x SP 6322-0.

Sucrose Percentage													
Location	Diseases		a/ :No. :	Entry no.									
	BR	CT:LS	Rh:reps:	1	2	3	4	5	6	7	8	Loc. b/ :check :	LSD c/ :(.05)
<u>Eastern area:</u>													
(1) Kanawha, Iowa	2-3	1	8	100	100	98	108	110	107	100	105	103	8
(2) Mason City, Iowa		1	9	100	96	93	102	99	99	95	95	100	3
(3) Beltsville, Md.	1	3	2	100	93	88	105	99	96	107	73	103	9
(4) E. G. F., Minn.			9	100	99	96	98	100	101	95	100	99	4
Aver., eastern area				100.0	97.0	93.8	103.3	102.0	100.8	99.3	93.3	101.3	
<u>Western area:</u>													
(5) Ham. City, Calif.		3	9	100	101	95	100	102	96	100	91	91	6
(6) Ft. Col., Colo.		3	9	100	100	100	105	106	105	98	99	99	2
(7) Roc.Ford, Colo.		1	9	100	99	93	102	103	101	99	89	99	3
(8) Two Buttes, Colo.	1-*		8	100	101	96	105	102	101	98	101		4
(9) Lakin, Kansas	1		8	100	101	96	104	103	102	100	103		4
(10) Tribune, Kansas	1-		5	100	95	96	103	101	99	99	94	100	4
(11) Hereford, Texas	*	1*	9	100	94	93	111	104	102	94	96	97	4
Aver., western area				100.0	98.7	95.6	104.3	103.0	100.9	98.3	96.1		
General aver., all locations				100.0	98.1	94.9	103.9	102.6	100.8	98.6	95.1		

a/ Disease exposure: BR = black root (Aphanomyces cochlidioides); CT = curly top (virus); LS = leaf spot (Cercospora beticola); Rh = Rhizoctonia root or crown rot; 1 = mild; 2 = moderate; 3 = severe. No numerical entry for a disease indicates negligible effects, if any. * = Chemical control measures applied.

b/ Local checks were as follows (location numbers in parentheses): (1) Am #3 Hybrid "A"; (2) Am #3 Hybrid "A"; (3) SP 643465-1 x SP 6322-0; (4) Am #3 Hybrid "A"; (5) HH 9; (6) GW 674-56C; (7) Am #2 Hybrid "A"; (10) National com. var. of 1966; (11) Holly no. 5224-013.

c/ LSD (.05) expressed as percent of the sucrose percentage of the standard variety.

Table 20.--Summary of leaf spot and curly top resistance results, cooperative tests of LSR-CTR varieties, 1967.

Description	Leaf spot grades										Curly top grades		C T %
	: Entry	: Ft.Col.*	: a/	: Belts.*	: a/	: H.City	: b/	: M.City	: c/	: S.J.Val.	: d/	: Thatcher*	
	: no.	: 8/27	: 9/25	: 8/31	: 8/24	: 8/24	: 8/24	: 8/24	: 8/24	: 8/3	: 9/25	: 8/16	
No. of replications	: 9	: 9	: 9	: 3	: 9	: 9	: 9	: 9	: 9	: 2	: 2	: 2	
SL(129 x 133) x SP 6322-0	1	4.2	3.8	4.2	5.0	3.0	4.0	2.5	4.0	2.5	2.5	41	
SP 65209-03 x FC 901	2	4.2	4.4	5.0	5.0	3.0	5.0	5.0	5.0	5.0	5.0	78	
SP 65406-01 x FC 901	3	4.0	4.2	4.2	5.4	2.5	3.8	2.5	3.8	2.5	2.5	38	
(FC502xMcF.648-3)xFC901	4	3.3	2.8	3.7	4.9	2.5	4.0	2.5	4.0	2.5	2.5	41	
FC(504x502/2)xFC 901	5	2.8	2.8	3.5	4.8	1.0	4.0	3.0	4.0	3.0	3.0	44	
FC(504x502/2)xMcF.663	6	3.3	3.5	3.3	4.8	2.0	4.5	3.0	4.5	3.0	3.0	50	
SP 5822-0 (LSR check)	7	3.2	2.9	3.2	4.0	1.0	5.0	5.5	5.0	5.5	5.5	84	
US H7 (CTR check)	8	5.0	5.2	6.2	6.3	4.5	2.5	3.0	2.5	3.0	3.0	23	
US 33											3.5	62	
US 41											2.5	39	

a/ Leaf spot grades, Fort Collins, Colo., and Beltsville, Md. (U.S.D.A.): 0 = no leaf spot; 10 = complete defoliation.

b/ Leaf spot grades, Hamilton City, Calif. (Holly Sugar Corp.): 0 = no leaf spot; 9 = complete defoliation.

c/ Leaf spot grades, Mason City, Iowa (American Crystal Sugar Co.--leaf spot nursery): 1 = resistant; 5 = susceptible.

d/ Curly top grades, San Joaquin Valley, Calif. (Spreckels Sugar Co.): 1 = no apparent stunting and less than 5% infected plants; 5 = severe stunting and 100% infected plants.

e/ Curly top grades, Thatcher, Utah (U.S.D.A.): 0 = no symptoms; 9 = dead.

* = Disease exposure intensified artificially.

Table 21a.--Description of cooperative agronomic evaluation test of LSR-CTR varieties, Kanawha, Iowa (Black Root Area), 1967.

Conducted By: American Crystal Sugar Company.

Location: Kanawha, Iowa.

Dates of Planting and Harvest: May 5; October 15.

Experimental Design: 3 x 3 Triple Lattice, 9 replications; plots 1 row x 25'; rows 22" apart. Only 8 replications used for harvest.

Determination of Root Yield: Weight of all beets per plot.

Determination of Sucrose Percentage: All harvested beets used.

Stand Count: Beet count at harvest.

Leaf Spot Exposure: Light.

Curly Top Exposure: None.

Other Diseases and Pests: Medium heavy Aphanomyces infestation.

Soil and Seasonal Conditions: Good.

Other Comments: Damage by Aphanomyces was very erratic. One replication had practically no beets. Mean squares for replications was very high, and this was the main feature of the test.

Reliability of Test: Poor.

Table 2lb.--Results of cooperative agronomic evaluation test of LSR-CTR varieties, Kanawha, Iowa (Black Root Area), 1967, (8-plot averages).

Description	Fort Collins		Entry		Acre yield		Impurity		Stand	
	seed no.	no.	no.	no.	Gross	Roots	Sucrose	index	(roots	per 25')
					Lbs.	Tons	%	%		No.
SL(129 x 133) x SP 6322-0	Acc. 2646	1			3952	18.28	10.81	876		25.6
SP 65209-03 x FC 901	Acc. 2675	2			3430	15.88	10.80	782		24.6
SP 65406-01 x FC 901	Acc. 2676	3			3333	15.75	10.58	916		28.0
(FC 502 x McF. 648-3) x FC 901	SP 661203H07	4			3763	16.07	11.71	715		25.9
FC(504 x 502/2) x FC 901	Acc. 2672	5			3494	14.72	11.87	686		26.2
FC(504 x 502/2) x McF.663	SP 661204H08	6			3543	15.30	11.58	754		23.8
SP 5822-0; LSR check	Acc. 2644	7			2873	13.35	10.76	789		25.1
US H7; CTR check	Acc. 2645	8			3330	14.63	11.38	828		24.6
Am #3 Hybrid "A", Local check		9			3333	14.93	11.17	940		26.0
General mean					3453	15.43	11.19	810		
L.S.D. (.05)					1031	---	.84	132		
L.S.D. (.01)					--	---	---	175		
F Value					--	NS	2.51*	3.54**		
C.V. %					29.79	28.84	7.52	16.26		

Variance Table b/

Source of Variation:D/F:	Roots	Mean squares (variance)	
		Sucrose:No. Roots:	Impurity
	(lbs.)	%	(25') : index %
Replicates	7	532.7042	1.5571 118.1428 54.6565
Varieties	8	64.5725	1.7812 11.5000 61.4997
Error	56	87.7551	0.7098 20.2678 17.3655
Total	71	129.0112	0.9141 28.9295 26.0150

* Significant at the 5% level

** Significant at the 1% level

a/ Impurity Index =

$$\frac{3.5 \text{ Na} + 2.5 \text{ K} + 9 \text{ Amino N}}{\text{Percent Sucrose}}$$

b/ For gross sucrose SE lbs. sucrose
= mean lbs. sucrose x

$$\sqrt{\frac{(\text{SE lbs.beets})^2}{(\text{Mean lbs.beets})} + \frac{(\text{SE \% sucrose})^2}{(\text{Mean \% sucrose})}}$$

Table 22a.--Description of cooperative agronomic evaluation test of LSR-CTR varieties, Mason City, Iowa, 1967.

Conducted By: American Crystal Sugar Company.

Location: Mason City, Iowa.

Dates of Planting and Harvest: May 10; October 10.

Experimental Design: 3 x 3 Triple Lattice; 9 replications; 2 row plots x 35'; rows 22" apart.

Determination of Root Yield: Weight of all beets per plot.

Determination of Sucrose Percentage: All beets per plot in convenient size samples.

Stand Count: Beets counted at harvest.

Leaf Spot Exposure: Light.

Curly Top Exposure: None.

Other Diseases and Pests: None.

Soil and Seasonal Conditions: Good.

Other Comments: Some variable stands.

Reliability of Test: Fair. .

Description	Fort Collins: seed no.	Entry: no.	Acre yield		Gross sucrose:	Roots	: Sucrose: a/ index	Impurity: (roots : spot a/ : per 70')	Stand : (roots : spot index)	Leaf b/
			Lbs.	Tons						
SL(129 x 133) x SP 6322-0	Acc. 2646	1	5685	20.32	13.99		718	65.1	3.0	
SP 65209-03 x FC 901	Acc. 2675	2	4889	18.16	13.46		736	56.2	3.0	
SP 65406-01 x FC 901	Acc. 2676	3	5329	20.48	13.01		877	49.2	2.5	
(FC 502 x McF.648-3) x FC 901	SP 661203H07	4	5256	18.39	14.29		693	63.2	2.5	
FC(504 x 502/2) x FC 901	Acc. 2672	5	4698	16.96	13.85		678	58.4	1.0	
FC(504 x 502/2) x McF.663	SP 661204H08	6	5267	19.07	13.81		800	59.5	2.0	
SP 5822-0; LSR check	Acc. 2644	7	4154	15.64	13.28		795	51.7	1.0	
US H7; CTR check	Acc. 2645	8	4819	18.20	13.24		872	57.3	4.5	
Am #3 Hybrid "A"; Local check		9	5039	18.06	13.95		842	63.9	3.0	
General mean			5019	18.37	13.66		779			
L.S.D. (.05)			681	2.40	.48		69			
L.S.D. (.01)			909	3.19	.63		93			
F Value			--	3.18**	7.35**		11.59**			
C.V. %			14.36	13.89	3.68		9.47			

Variance Table $\frac{c}{\text{---}}$

Source of Variation	D/F	Mean squares (variance)			
		Roots : (lbs.)	%	Sucrose : (70')	No. Roots: Impurity : index %
Replicates	8	248.4462	.2537	112.6250	34, 142
Component (a)	12	186.8375	.5350	26.5833	12, 492
Component (b)	6	40.9883	.2283	35.8333	12, 385
BBlocks	18	138.2211	.4328	29.6666	12, 456
Varieties	8	718.1400	1.6075	264.5000	51, 986
Error	46	260.5136	.2186	38.5652	4, 484
Total	80	277.5537	.4092	66.5625	13, 994

$$\frac{a/}{\text{Impurity Index} = \frac{3.5 \text{ Na} + 2.5 \text{ K} + 9 \text{ Amino N}}{\text{Percent Sucrose}}}$$

b/ Leaf spot Index obtained from Mason City Leaf Spot Nursery: 1 = resistant; 5 = susceptible.

** Significant at the 1% level.

$$\frac{c}{\text{For gross sucrose SE lbs. Sucrose} = \text{mean lbs. sucrose} \times \sqrt{\frac{(\text{SE lbs. beets})^2}{(\text{Mean lbs. beets})} + \frac{(\text{SE \% sucrose})}{(\text{Mean \% sucrose})}}$$

Table 23a.--Description of cooperative agronomic evaluation test of LSR-CTR varieties, Beltsville, Maryland, 1967.

Conducted By: G. E. Coe.

Location: South Farm, Plant Industry Station, Beltsville, Maryland; Field No. SF-11.

Dates of Planting and Harvest: April 19; October 20.

Experimental Design: Randomized Block, 3 replications; plots 4 rows x 20'; rows 24" apart; hand-thinned to single-plant hills.

Determination of Root Yield: All the roots in each of the center 2 rows were hand topped and weighed separately.

Determination of Sucrose and Purity Percentage: The first 10 roots in each of the center 2 rows were the 2 samples from each plot analyzed for sucrose and raw juice refractometer determinations.

Stand Counts: The number of roots harvested were counted.

Recent Cropping History: 1963-1966, sugarbeet.

Chemicals Applied for 1967 Crop: 5000 lbs. limestone per acre in January, 1967; 500 lbs. 10-6-4 with 2% borax added applied as side dressing in May.

Leaf Spot Exposure: Severe.

Black Root Exposure: Mild.

Crown Rhizoctonia: Moderate.

Other Diseases and Pests: Savoy, incidental; other diseases and pests, negligible.

Soil and Seasonal Condition: An average crops season was experienced in 1967 with the exception of heavy rains in the latter part of August and a flood which inundated the plot on August 24. Sprinkler irrigation was used only when the beets were emerging after a rain caused the soil to crust, and to keep the leaves moist for a week after leaf spot inoculation (June 19) to promote development of the disease.

Reliability of Test: Fair. The severe leaf spot epidemic heavily favored those varieties with leaf spot tolerance. Crown Rhizoctonia was the main contributor to variation between rows in number of roots and root yield.

Table 23b.--Results of cooperative agronomic evaluation test of LSR-CTR varieties, Beltsville, Maryland, 1967 (3-plot average).

Description	Fort Collins		Entry		Acres yield		Leaf a/Plants		Raw juice	
	seed no.	no.	sucrose:	Roots	Gross	no.	8/31	per	apparent	purity
			Lbs.	Tons	%	No.	%	100'	%	
SL(129 x 133) x SP 6322-0	Acc. 2646	1	3899	16.14	12.12	83	4.2	83	81.2	
SP 65209-03 x FC 901	Acc. 2675	2	3626	16.08	11.23	98	5.0	98	81.3	
SP 65406-01 x FC 901	Acc. 2676	3	3692	17.39	10.62	89	4.2	89	79.8	
(FC 502 x McF.648-3) x FC 901	SP 661203HO7	4	3630	14.33	12.70	85	3.7	85	83.1	
FC(504 x 502/2) x FC 901	Acc. 2672	5	3634	15.50	12.00	89	3.5	89	82.7	
FC(504 x 502/2) x McF.663	SP 661204HO8	6	4044	17.50	11.62	88	3.3	88	80.6	
SP 5822-0; LSR check	Acc. 2644	7	4088	15.79	12.97	85	3.2	85	82.5	
US H7; CTR check	Acc. 2645	8	1937	11.00	8.87	70	6.2	70	76.7	
SP 643465-1 x SP 6322-0; loc.ck.		9	4499	18.21	12.48	91	3.2	91	80.6	
General mean			3672	15.77	11.62	86	4.1	86	81.0	
S. E. of var. mean			204	.67	.346		.26		2.25	.63
S. E. of var. mean as % of gen. mean			5.55	4.27	2.98		6.39		2.60	.78
L.S.D. (.05)			740	3.10	1.15		.58		10	3.30

Variance Table

Source of variation	D/F		Gross		Roots		Mean square (variance)		Leaf spot		No. plants		Raw juice ap-	
	:	:	sucrose	:	sucrose	:	Sucrose	:	Leaf spot	:	plants	:	parent	purity
Replications	2		355,797		25.9312		2.6100		.48		62.00		4.5249	
Varieties	8		24,380,400		219.9921		17.1558		43.48		2664.83		179.0207	
R x V	16		4,182,562		73.1268		4.6650		2.52		829.67		83.0622	
Remainder	27		6,445,229		117.2480		13.3400		4.98		2374.98		96.2870	
Total	54		763,616,825		13864.4532		7,391.8000		923.00		409,800.00		354,334.5881	
Reduction	27		757,171,837		13747.2051		7,378.4400		918.50		407,425.00		354,238.3011	
Mu	1		728,253,078		13428.1551		7,294.1100		872.02		403,868.50		353,911.6933	
Calculated F value for var.			12.77**		6.33**		19.55**		29.47**		3.79**		6.28**	

a/ Leaf spot: 0 = no leaf spot; 10 = complete defoliation.

** F exceeds the 1% point.

Table 24a.--Description of cooperative agronomic evaluation test of LSR-CTR varieties, East Grand Forks, Minnesota, 1967.

Conducted By: American Crystal Sugar Company.

Location: East Grand Forks, Minnesota Factory Farm.

Dates of Planting and Harvest: May 20; October 2.

Experimental Design: 3 x 3 Triple Lattice, 9 replications; plots 2 rows x 35'; rows 22" apart.

Determination of Root Yield: Weight of all beets per plot.

Determination of Sucrose Percentage: Two samples per plot.

Stand Count: Count of beets at harvest.

Leaf Spot Exposure: None.

Curly Top Exposure: None.

Other Diseases and Pests: None.

Soil and Seasonal Conditions: Extremely dry season.

Other Comments: No rain from July 7 until October 1.

Reliability of Test: Excellent.

Table 24b.--Results of cooperative agronomic evaluation test of LSR-CTR varieties, East Grand Forks, Minnesota, 1967, (9-plot averages).

Description	Fort Collins seed no.	Entry no.	Acre yield		Sucrose index	Impurity a/ index	Stand (roots per 70')
			Gross	Roots			
			Lbs.	Tons	%	%	No.
SL(129 x 133) x SP 6322-0	Acc. 2646	1	5863	17.44	16.81	392	68.8
SP 65209-03 x FC 901	Acc. 2675	2	5514	16.64	16.57	464	65.0
SP 65406-01 x FC 901	Acc. 2676	3	5202	16.15	16.12	458	61.2
(FC 502 x McF.648-3) x FC 901	SP 661203H07	4	4877	14.87	16.40	428	64.7
FC(504 x 502/2) x FC 901	Acc. 2672	5	5229	15.58	16.78	416	66.7
FC(504 x 502/2) x McF. 663	SP 661204H08	6	5600	16.56	16.91	445	66.7
SP 5822-0; LSR check	Acc. 2644	7	4346	13.59	15.99	439	60.7
US H7; CTR check	Acc. 2645	8	5229	15.60	16.76	483	66.9
Am #3 Hybrid "A"; Local check	.	9	4993	15.02	16.62	488	66.9
General mean			5203	15.72	16.55	446	
L.S.D. (.05)			382	1.01	.59	44	
L.S.D. (.01)			510	1.34	---	59	
F Value			--	10.21**	2.84*	4.51**	
C.V.%			7.77	6.82	3.74	10.49	

Variance Table				b/	
Source of Variation	D/F	Roots (lbs.)	Mean squares (variance)	a/	
				Impurity Index = 3.5 Na + 2.5 K + 9 Amino N Percent Sucrose	
Replicates	8	447.6912	0.4537	396.2500	3.6190
Component (a)	12	40.3666	0.7333	15.9166	3.4197
Component (b)	6	34.5383	0.6833	15.8333	2.9576
Blocks	18	38.4238	0.7166	15.8888	3.2657
Varieties	8	408.7825	0.9262	67.0000	8.7760
Error	46	40.6700	0.3267	17.8261	1.9445
Total	80	117.6780	0.4871	24.4875	3.0924

$$\sqrt{\frac{(\text{SE lbs. beets})^2}{(\text{Mean lbs. beets})} + \frac{(\text{SE \% sucrose})^2}{(\text{Mean \% sucrose})}}$$

b/ For gross sucrose SE lbs. sucrose
= mean lbs. sucrose x

* Significant at the 5% level
** Significant at the 1% level

Table 25a.-- Description of cooperative agronomic evaluation test of LSR-CTR varieties, Hamilton City, California, 1967.

Conducted by: J. L. Purdy.

Location: Hamilton City, California.

Cooperation: Holly Sugar Corporation and M & T Inc.

Dates of Planting and Harvest: March 7; October 24.

Experimental Design: Latin Square, 9 x 9; plots 2 rows x 53'; rows 30" apart.

Determination of Root Yield: Two rows x 50' in each plot.

Determination of Sucrose Percentage: Two 25-lb. samples per plot.

Leaf Spot Exposure: Severe.

Curly Top Exposure: Mild, if any.

Other Diseases: Negligible.

Reliability of Test: Good.

Remarks: The test was flat planted and sprinkler irrigated.

Table 25b.--Results of cooperative agronomic evaluation test of LSR-CTR varieties, Hamilton City, California, 1967 (9-plot averages).

Description	Fort Collins: seed no.	Entry: no.	Acre yield		Beets per 100'	Leaf ^{a/} spot 8/24	Tot. bol- ters
			Gross sucrose:	Roots %			
			Lbs.	Tons	%	No.	
SL(129 x 133) x SP 6322-0	Acc. 2646	1	3414	14.249	11.98	88.5	159 5.0 2
SP 65209-03 x FC 901	Acc. 2675	2	3712	15.379	12.07	89.2	153 5.0 4
SP 65406-01 x FC 901	Acc. 2676	3	4262	18.776	11.35	87.7	150 5.4 0
(FC 502 x McF. 648-3) x FC 901	SP 661203HO7	4	3838	16.059	11.95	89.0	155 4.9 0
FC(504 x 502/2) x FC 901	Acc. 2672	5	4101	16.782	12.22	89.0	161 4.8 0
FC(504 x 502/2) x McF. 663	SP 661204HO8	6	4034	17.479	11.54	87.2	166 4.8 0
SP 5822-0 (LSR check)	Acc. 2644	7	2780	11.553	12.03	89.2	147 4.0 8
US H7 (CTR check)	Acc. 2645	8	3428	15.669	10.94	86.8	160 6.3 0
HH 9 (local check)		9	3770	17.325	10.88	86.1	165 5.1 0
General mean			3704	15.919	11.66	88.1	
S. E. of the mean			154 ^{b/}	.564	.25	.55	
SEM/general mean (%)			4.16	3.54	2.18	.63	
LSD (5%)			435	1.594	.72	1.56	

Variance Table

Variation due to	D/F	Mean square (variance)	
		Tons beets:%	sucrose:% purity
Variety	8	39.986	2.297 12.245
Replication	8	11.202	.654 2.219
Error	64	2.861	.581 2.751
Total	80		
Calculated F value		13.977**	3.95** 4.451**

^{a/} Leaf spot ratings: 0 = no infection; 9 = complete defoliation.

^{b/} Short cut formula.

** Exceeds the 1% level (2.79).

Table 26a.--Description of cooperative agronomic evaluation test of LSR-CTR varieties, Fort Collins, Colorado, 1967 (Exp. 1A).

Conducted by: J. O. Gaskill and L. W. Lawson.

Location: Hospital Farm, Fort Collins, Colorado; field no. 1.

Cooperation: Colorado Agricultural Experiment Station, and the Beet Sugar Development Foundation.

Dates of Planting and Harvest: April 28; October 23.

Experimental Design: Latin Square, 9 x 9; plots 2 rows x 20'; rows 20' apart; hand thinned to single-plant hills.

Determination of Root Yield: All roots in an accurately measured area (usually about 36' and not less than 31' of row) in each plot were topped, washed, and weighed.

Determination of Sucrose and Purity Percentages: All roots harvested for yield determination in each plot were divided into 2 samples for sucrose and purity analyses. Sucrose analyses were made in duplicate for each root sample.

Stand Counts: All living plants in the area to be harvested in each plot were counted just before harvest.

Recent Cropping History: 1964, sugarbeets; 1965-66, barley.

Chemicals Applied for 1967 Crop: Treble superphosphate (approx. 120 lbs. P_2O_5 per acre) and ammonium nitrate (about 98 lbs. N per acre) were applied before plowing in August, 1966. Additional ammonium nitrate (approx. 37 lbs. N per acre) was applied in March, 1967. Shell "DD" (55 gal. per acre) was applied on September 6, 1966, for nematode control. Dylox bait was applied to border areas several times in May, 1967, for control of root maggot adults. A topical application of Disyston granules was made on July 6, 1967, for aphid control.

Leaf Spot Exposure: Severe.

Curly Top Exposure: Negligible.

Other Diseases and Pests: Effects of western yellows, sugarbeet nematode, Rhizoctonia, and root maggot were mild. Gaps in stand in any given plot (e.g. due to Rhizoctonia and root maggot) were excluded from the area harvested for root yield and laboratory analyses.

Soil and Seasonal Conditions: The soil was classed as Fort Collins loam, light-textured phase. The 1967 crop season was unusually cold and wet until the middle of July and about normal thereafter. Adequate soil moisture was provided artificially as needed throughout the season, principally by furrow irrigation. Inoculation (July 10) and subsequent frequent sprinkling were used to promote the development of leaf spot (Cercospora beticola).

Reliability of Test: Excellent.

Table 26b.--Results of cooperative agronomic evaluation test of LSR-CTR varieties, Fort Collins, Colorado, 1967 (Exp. 1A, 9-plot averages).

Description	Fort Collins		Entry		Acre yield		Appar--		Leaf spot		Stand	
	seed no.	no.	sucrose	Gross	Roots	Sucrose	ent	a/	(Hills	Bolt-	ers	
				Lbs.	Tons	%	%			No.	%	
SL(129 x 133) x SP 6322-0	Acc. 2646	1	4706	14.51	16.22	84.82	4.2	3.5	3.8	124	0.0	
SP 65209-03 x FC 901	" 2675	2	4409	13.55	16.29	84.53	4.2	3.7	4.4	124	0.0	
SP 65406-01 x "	" 2676	3	5486	16.87	16.25	84.96	4.0	3.4	4.2	125	0.0	
(FC 502 x McF.648-3) x "	SP 661203H07	4	5001	14.70	17.01	84.44	3.3	2.7	2.8	122	0.0	
FC(504 x 502/2) x "	Acc. 2672	5	5424	15.80	17.16	86.14	2.8	2.3	2.8	123	0.0	
FC(504 x 502/2) x McF.663	SP 661204H08	6	5622	16.58	16.97	84.37	3.3	2.9	3.5	125	0.2	
SP 5822-0 (LSR check)	Acc. 2644	7	4141	12.98	15.95	83.59	3.2	2.5	2.9	120	0.0	
US H7 (CTR check)	" 2645	8	4516	14.14	15.99	85.18	5.0	4.5	5.2	126	0.0	
GW 674-56C (Local check)	" 2168	9	4678	14.63	15.99	84.40	3.8	3.3	4.2	123	0.0	
General mean			4887.03	14.862	16.43	84.72	3.77	3.20	3.77	123.60		
S. E. of var. mean			79.26	.235	.09	.45	.12	.10	.13	1.07		
S. E. of var. mean as % of gen. mean			1.62	1.58	.56	.53	3.09	3.06	3.37	.87		
L.S.D. (.05)			224	.66	.26	1.27	.33	.28	.36	3.03		

Variance Table

Source of variation:		D/F:		Mean square (variance)						
				Gross sucrose		Roots	Sucrose	%App. purity:	L.S.8/27:L.S.9/11:L.S.9/25:Stand	
Blocks	8	211,043	2.469	0.166	2.081	0.193	0.244	0.360	84.29	
Columns	8	187,532	1.740	1.344	6.030	0.179	0.251	0.443	18.18	
Varieties	8	2,476,190	15.610	2.119	4.403	4.096	4.195	6.061	33.45	
Error(remainder)	56	56,538	0.495	0.077	1.820	0.121	0.086	0.145	10.33	
Total	80									
Calculated F value		43.80**	31.52**	27.60**	2.42*	33.72**	48.73**	41.72**	3.24**	

a/ Leaf spot readings (B. A. Nelsen): 0 = no leaf spot; 10 = complete defoliation.

* F exceeds the 5% point.

** F exceeds the 1% point.

Table 27a.--Description of cooperative agronomic evaluation test of LSR-CTR varieties, Rocky Ford, Colorado, 1967.

Conducted By: American Crystal Sugar Company.

Location: Rocky Ford, Colorado.

Dates of Planting and Harvest: April 14; October 10.

Experimental Design: Triple Lattice, 9 replications; plots 2 rows x 35'; rows 22" apart.

Determination of Root Yield: Total plot weight.

Determination of Sucrose Percentage: All beets from plot - 5 or 6 samples.

Stand Counts: Plots thinned, and rechecked in late June. Final field stand count used.

Leaf Spot Exposure: Very light.

Curly Top Exposure: Occasional plants affected late in season.

Other Diseases and Pests: None.

Soil and Seasonal Conditions: Good.

Other Comments: US H7, the CTR check had an appreciable amount of leaf spot.

Reliability of Test: An excellent test under excellent growing conditions.

Table 27b.--Results of cooperative agronomic evaluation test of LSR-CTR varieties, Rocky Ford, Colorado, 1967 (9-plot averages).

Description	Fort Collins seed no.	Entry no.	Acre yield		Sucrose	Impurity index	Stand (roots per 70')
			Gross	Roots			
			Lbs.	Tons	%	%	No.
SL(129 x 133) x SP 6322-0	Acc. 2646	1	7951	26.54	14.98	598	66.7
SP 65209-03 x FC 901	Acc. 2675	2	7125	23.91	14.90	642	66.1
SP 65406-01 x FC 901	Acc. 2676	3	7249	26.00	13.94	746	66.1
(FC 502 x McF.648-3) x FC 901	SP 661203H07	4	6828	22.24	15.35	592	64.4
FC(504 x 502/2) x FC 901	Acc. 2672	5	7732	25.04	15.44	588	65.9
FC(504 x 502/2) x McF.663	SP 661204H08	6	7786	25.80	15.09	675	64.4
SP 5822-0; LSR check	Acc. 2644	7	6945	23.37	14.86	577	61.8
US H7; CTR check	Acc. 2645.	8	5701	21.40	13.32	876	67.0
Am #2 Hybrid "A"; local check		9	6815	22.90	14.88	682	65.8
General mean			7121	24.14	14.75	664	
L.S.D. (.05)			669	2.18	.40	59	
L.S.D. (.01)			893	2.90	.53	79	
F value			---	6.04**	24.72**	22.13**	
C.V. %			9.94	9.52	2.87	9.49	

Variance Table

Source of variation	D/F	Mean squares (variance)		Impurity index %	Percent Sucrose
		Roots (ozs.)	Sucrose %		
Replicates	8	46,302	1.4750	28.2500	6,361
Component (a)	12	81,023	0.3167	17.2500	4,173
Component (b)	6	17,334	0.0750	39.1667	4,745
Blocks	18	59,793	0.2361	24.5555	4,364
Varieties	8	261,547	4.2250	23.0000	85,067
Error	46	43,327	0.1709	10.2826	3,844
Total	80	69,152	0.7214	16.5625	12,335

a/ Impurity Index = $\frac{3.5\text{Na}+2.5\text{K}+9\text{Amino N}}{\text{Percent Sucrose}}$
 ** = Significant at the 1% level.

b/ For gross sucrose SE lbs. sucrose = mean lbs. sucrose x

$$\sqrt{\frac{(\text{SE lbs. Beets})^2}{(\text{Mean lbs.beets})} + \frac{(\text{SE \% sucrose})^2}{(\text{mean \% sucrose})}}$$

Table 28a.--Description of cooperative agronomic evaluation test of LSR-CTR varieties, Two Buttes, Colorado, 1967.

Conducted By: American Crystal Sugar Company.

Location: Two Buttes, Colorado.

Dates of Planting and Harvest: April 7; October 20.

Experimental Design: Randomized Block, 8 replications; plots 2 rows x 35'; rows 24" apart.

Determination of Root Yield: Weight of all beets per plot.

Determination of Sucrose Percentage: All beets per plot in 5 or 6 samples.

Stand Count: Field count at harvest.

Leaf Spot Exposure: Very light - sprayed three times with Maneb.

Curly Top Exposure: Practically none.

Other Diseases and Pests: Practically none.

Soil and Seasonal Conditions: Good.

Other Comments: An excellent test under ideal conditions.

Reliability of Test: Excellent.

Table 28b.--Results of cooperative agronomic evaluation test of LSR-CTR varieties, Two Buttes, Colorado, 1967 (8-plot averages).

Description	: Fort Collins :			Entry:			Acre yield			: Impurity :			Stand		
	: seed no.	: no.	:	: no.	:	:	: Gross	: Roots	:	: Sucrose	: index	:	: (roots	:	: per 70')
							Lbs.	Tons		%	%		No.		
SL(129 x 133) x SP 6322-0	Acc. 2646	1					9948	29.82		16.68	522		69.1		
SP 65209-03 x FC 901	Acc. 2675	2					9729	28.99		16.78	561		68.5		
SP 65406-01 x FC 901	Acc. 2676	3					10925	34.12		16.01	611		68.6		
(FC 502 x McF.648-3) x FC 901	SP 661203HO7	4					9852	28.07		17.55	459		67.1		
FC(504 x 502/2) x FC 901	Acc. 2672	5					9738	28.64		17.00	477		69.1		
FC(504 x 502/2) x McF. 663	SP 661204HO8	6					10538	31.16		16.91	556		69.5		
SP 5822-0; LSR check	Acc. 2644	7					8857	27.17		16.30	573		66.4		
US H7; CTR check	Acc. 2645	8					10171	30.29		16.79	597		70.0		
General mean							9976	29.78		16.75	545				
L.S.D. (.05)							822	2.21		.60	42				
L.S.D. (.01)							1098	2.95		.79	56				
F Value							---	7.70**		4.76**	13.76**				
C.V. %							8.21	7.40		3.56	7.62				

Variance Table b/

Source of Variation: D/F:	Mean squares (variance)		
	:Roots (ozs.):	Sucrose %:	No. Roots (70'):Impurity index %
Replicates	7	54,315	2.4171
Varieties	7	395,771	1.6942
Error	49	51,404	0.3559
Total	63	89,990	0.7337

a/ Impurity Index = $\frac{3.5 \text{ Na} + 2.5 \text{ K} + 9 \text{ Amino N}}{\text{Percent Sucrose}}$

b/ For gross sucrose SE lbs. sucrose = mean lbs. sucrose $\times \sqrt{\frac{(\text{SE lbs. beets})^2}{(\text{Mean lbs. beets})} + \frac{(\text{SE \% sucrose})^2}{(\text{Mean \% sucrose})}}$

** Significant at the 1% level.

Table 29a.--Description of cooperative agronomic evaluation test of LSR-CTR varieties, Lakin, Kansas, 1967.

Conducted By: American Crystal Sugar Company.

Location: Lakin, Kansas.

Dates of Planting and Harvest: May 25; November 15-16.

Experimental Design: Randomized Block, 8 replications; plots 2 rows x 35'; rows 24" apart.

Determination of Root Yield: Weight of all beets per plot.

Determination of Sucrose Percentage: All beets per plot in 5 or 6 samples.

Stand Count: Field count at harvest.

Curly Top Exposure: Practically none.

Other Diseases and Pests: Practically none.

Soil and Seasonal Conditions: Good.

Other Comments: One of the last plantings made in this area in 1967.

Reliability of Test: Excellent.

Table 29b.--Results of cooperative agronomic evaluation test of LSR-CTR varieties, Lakin, Kansas, 1967, (8-plot averages).

Description	:Fort Collins:		:Acre yield:		:Impurity:		:Stand:		:Raffinose	
	: seed no. :	: no. :	: Gross : Roots :	: % :	: index a/ : per 70' :	: % :	: (roots : a/ : per 70' :	: No. :	: % on D.S. :	: % :
SL(129 x 133) x SP 6322-0	Acc. 2646	1	6148	19.96	15.40	680	64.1		.306	
SP 65209-03 x FC 901	Acc. 2675	2	6064	19.55	15.51	718	62.0		.201	
SP 65406-01 x FC 901	Acc. 2676	3	7037	23.71	14.84	782	68.9		.190	
(FC 502 x McF.648-3) x FC 901 SP 661203H07		4	6265	19.47	16.09	586	68.3		.296	
FC(504 x 502/2) x FC 901	Acc. 2672	5	6652	20.92	15.90	619	63.6		.192	
FC(504 x 502/2) x McF.663	SP 661204H08	6	7080	22.52	15.72	673	66.1		.208	
SP 5822-0; LSR check	Acc. 2644	7	6396	20.78	15.39	683	60.4		.306	
US H7; CTR check	Acc. 2645	8	6276	19.85	15.81	714	65.4		.204	
General mean			6494	20.84	15.58	682			.238	
L.S.D. (.05)			571	1.82	.54	76			.044	
L.S.D. (.01)			760	2.42	.72	101			.058	
F Value			--	5.71**	4.14**	5.10**			12.16**	
C.V. %			8.77	8.69	3.47	11.10			18.44	

Variance Table b/

Source of variation:D/F:		Mean squares (variance)				
:	:	Roots	Sucrose	Stand	Impurity	Raffinose
:	:	(ozs.)	%	(70')	index %	% on D.S.
Replicates	7	318,435	3.9600	5.2857	152,632	.00123
Varieties	7	198,164	1.2128	68.2857	29,230	.02347
Error	49	34,704	.2928	15.8571	5,731	.00193
Total	63	84,392	.8025	20.5079	24,665	.00425
a/	Impurity Index = $\frac{3.5 \text{ Na} + 2.5 \text{ K} + 9 \text{ Amino N}}{\text{Percent Sucrose}}$					

b/ For gross sucrose SE lbs. Sucrose = mean lbs. sucrose x $\sqrt{\frac{(\text{SE lbs. beets})^2}{(\text{Mean lbs. beets})} + \frac{(\text{SE \% sucrose})^2}{(\text{Mean \% sucrose})}}$

** Significant at the 1% level.

Table 30a.--Description of cooperative agronomic evaluation test of LSR-CTR varieties, Tribune, Kansas, 1967.

Conducted By: Roy E. Gwin, Jr.

Location: Tribune Branch Station, Kansas Agricultural Experiment Station, Tribune, Kansas.

Cooperation: Kansas Agricultural Experiment Station and the Great Western Sugar Company.

Date of Planting: April 10.

Experimental Design: Randomized block; 5 replications; plots 6 rows x 30'; rows 22" apart; hand thinned.

Determination of Root Yield: Two rows x 15' in each plot.

Determination of Sucrose Percentage: One sample per plot (approximately 30 lbs. per sample).

Stand Counts: Harvested roots.

Preceding Crop: Wheat.

Chemicals Applied for Sugarbeet Crop: 100# per acre of 18-46-0 fertilizer; 70# of anhydrous ammonia; and 100# of a fertilizer mixture containing 5% zinc and other fertilizer material.

Leaf Spot Exposure: Very mild.

Curly Top Exposure: None.

Other Diseases and Pests: Negligible.

Reliability of Test: Fair.

Table 30b.--Results of cooperative agronomic evaluation test of LSR-CTR varieties, Tribune, Kansas, 1967 (5-plot averages).

Description	Fort Collins seed no.	Entry no.	Acre yield		Stand (roots per 100')
			Gross sucrose	Roots Tons	
SL(129 x 133) x SP 6322-0	Acc. 2646	1	Lbs. 9842	28.72	No. 144
SP 65209-03 x FC 901	Acc. 2675	2	9918	30.39	147
SP 65406-01 x FC 901	Acc. 2676	3	12516	38.03	145
(FC 502 x McF. 648-3) x FC 901	SP 661203H07	4	9866	28.00	153
FC(504 x 502/2) x FC 901	Acc. 2672	5	11106	32.09	155
FC(504 x 502/2) x McF. 663	SP 661204H08	6	10511	31.01	137
SP 5822-0; LSR check	Acc. 2644	7	11457	33.64	140
US H7; CTR check	Acc. 2645	8	10410	32.31	141
National reg. com'l. of 1966; loc. ck.		9	9961	28.97	149
General mean			10620.71	31.4613	145.67
S. E. of var. mean			442.97	1.2380	6.57
S. E. of var. mean as % of gen. mean			4.17	3.93	1.48
L.S.D. (.05)			1278	3.57	19

Variance Table

Source of variation	D/F	Mean square (variance)		
		Gross sucrose	Roots	Sucrose % Stand
Replications	4	2,022,313	10.3282	0.5475
Varieties	8	4,180,768	47.5919	1.3588
Error	31	981,158	7.6638	0.3148
Total	43			215.87
Calculated F value		4.26**	6.21**	4.32**
				0.82

a/ Results estimated for one "missing plot".

** Exceeds 1% point of significance.

Table31a.--Description of cooperative agronomic evaluation test of LSR-CTR varieties, Hereford, Texas, 1967.

Conducted by: D. F. Peterson, R. H. Helmerick, and Paul R. Scott.

Location: Eddie Reinauer farm, Hereford, Texas.

Cooperation: Holly Sugar Corporation and Eddie Reinauer.

Dates of Planting and Harvest: March 20; October 28.

Experimental Design: Randomized Block, 9 x 9; plots 1 row x 28'; rows 30" apart.

Determination of Root Yield: All roots in a 25' section of each plot.

Determination of Sucrose Percentage: Two 10-beet samples per plot.

Leaf Spot Exposure: Leaf spot exposure was mild in this test due to repeated applications of Kocide (commercial spray program) on the entire field.

Curly Top Exposure: Curly top exposure was negligible. This presumably was due, in part, to a preplanting application of Thimet for curly top control.

Other Diseases and Pests: Negligible.

Remarks: Fertility, stand, and general vigor and health of the crop were good. The leaf spot and curly top control programs (Kocide and Thimet, respectively) were representative of commercial practices in the Hereford area in 1967.

Reliability of Test: Very good.

Table3lb.--Results of cooperative agronomic evaluation test of LSR-CTR varieties, Hereford, Texas, 1967 (9-plot averages).

Description	Fort Collins:		Entry:		Acre yield		Beets:		Leaf a/ : per 100': spot : of row: 9/15
	: seed no.:		no.:		Gross : Roots		: Sucrose :		
	: Acc.:		: no.:		: sucrose :		: %:		
					Lbs.	Tons		No.	
SL (129 x 133) x SP 6322-0	Acc.	2646	1	7758	31.530	12.29	155	1.4	
SP 65209-03 x FC 901	Acc.	2675	2	7006	30.348	11.53	125	1.4	
SP 65406-01 x FC 901	Acc.	2676	3	8388	36.546	11.48	127	1.3	
(FC 502 x McF. 648-3) x FC 901	SP	661203HO7	4	8514	31.213	13.63	151	1.0	
FC(504 x 502/2) x FC 901	Acc.	2672	5	8664	33.753	12.83	128	1.1	
FC(504 x 502/2) x McF. 663	SP	661204HO8	6	9136	36.266	12.59	143	1.0	
SP 5822-0 (LSR check)	Acc.	2644	7	7248	31.326	11.59	124	1.0	
US H7 (CTR check)	Acc.	2645	8	7589	32.089	11.83	147	2.0	
5224-013 (local check)			9	7321	30.707	11.92	116	2.2	
General mean				7958	32.642	12.19	135		
S.E. of var. mean				285	1.071	.177			
LSD (.05)				807	3.03	.50			
LSD (.01)				1073	4.03	.66			
C.V. %				10.76	9.84	4.35			

a/ Leaf spot ratings (J. O. Gaskill): 0 = no leaf spot; 10 = complete defoliation.
 ** F exceeds the 1% point.

Variance Table			
Source of Variation:	D/F	Mean square(variance)	:Beets(tons): Sucrose %
Replications	8	5.691	.539
Varieties	8	49.419	4.673
Residual	64	10.315	.281
Total	80		
Calculated F value		4.79**	16.63**

A Study of the Varietal Response of
Sugarbeets to Postemergence Herbicides

Technical personnel: USDA, E. E. Schweizer (Research Plant Physiologist, Weed Investigations - Agronomic Crops) and J. O. Gaskill (Research Plant Pathologist, Sugarbeet Investigations)

In the 1966 Sugarbeet Research Report (2) we reported that three herbicide treatments applied postemergence reduced the weight of 8 varieties of sugarbeets markedly. The variety GW 674-56C was injured the most, whereas, the variety FC(502 x 503) x FC 901 was injured the least. We felt that since certain varieties were injured more than others we ought to repeat this study in 1967. Varieties were selected from what is known as the "Cooperative Evaluation Tests of LSR-CTR Sugarbeet Varieties, 1967".

Our primary objective was to determine what effect three herbicides applied postemergence would have on these varieties.

The results from this experiment are summarized in Table 32. The weight of tops was reduced by all postemergence treatments when compared to the untreated check for each variety. The variety FC(504 x 502/2) x McF. 663 (entry 6) was injured the least by the three post-emergence treatments, whereas the variety GW 674-56C (entry 9) was injured the most again in 1967.

The postemergence mixture of 2 lb/A of pyrazon plus 0.75 lb/A of S6173 reduced the weight of tops most, whereas, the postemergence mixture of 2 lb/A of pyrazon plus 1.1 lb/A of dalapon reduced the weight of tops the least. Six varieties produced more (statistically) top growth than variety GW 674-56C when sprayed with 0.75 lb/A of S6173, whereas, only 2 varieties produced more growth than variety GW 674-56C when treated with the postemergence mixture of pyrazon plus S6173.

In summary, varieties differed in the degree of top injury resulting from herbicides applied postemergence. Some varieties were more tolerant to one herbicide than another. The varieties, SL(129 x 133) x SP 6322-0 and GW 674-56C, were injured the most (mean weight of three herbicide treatments), whereas, the variety, FC(504 x 502/2) x McF. 663, was injured the least. Additional greenhouse and field research will be conducted in 1968.

Table 32b.--Response of LSR-CTR sugarbeet varieties to postemergence herbicides in the greenhouse, Fort Collins, Colorado, 1967-68.

Description	Fort Collins: Entry:		% of untreated tops (dry weight):			
	seed no.	no.	S6173	S6173 + pyrazon	pyrazon + dalapon	Mean
			0.75 lb/A	0.75 + 2 lb/A	2 + 1.1 lb/A	
SL(129 x 133) x SP 6322-0	Acc. 2646	1	48	39	47	45
SP 65209-03 x FC 901	Acc. 2675	2	56	35	64	52
SP 65406-01 x FC 901	Acc. 2676	3	40	34	63	46
(FC 502 x McF. 648-3) x FC 901	SP 661203H07	4	67	55	53	58
FC(504 x 502/2) x FC 901	Acc. 2672	5	57	51	54	54
FC(504 x 502/2) x McF. 663	SP 661204H08	6	68	57	55	60
SP 5822-0 (LSR check)	Acc. 2644	7	62	24	52	46
US H7 (CTR check)	Acc. 2645	8	54	48	63	55
GW 674-56C (local check)	Acc. 2168	9	30	28	64	41
	Mean		53	41	57	

LSD (19:1): Between variety means for all herbicide treatments 17; between herbicide means for all variety means 10; and between variety means for each herbicide treatment 23.

Variance Table

Source of variation : D/F : mean square : F value :			
Replicates	3	329.99	1.26
Treatments	26	612.95	2.34**
Varieties (V)	8	540.31	2.06*
Herbicides (H)	2	2,520.26	9.61**
V x H	16	410.85	1.57
Error	78	262.10	- -
Total	107		

Table 32a.--Description of herbicide resistance evaluation test of LSR-CTR sugarbeet varieties under greenhouse conditions, Fort Collins, Colorado, 1967-68.

Conducted By: E. E. Schweizer and J. O. Gaskill.

Location: Colorado State University, Fort Collins, Colorado.

Cooperation: Colorado Agricultural Experiment Station.

Date of Planting: November 13 (15 seeds per pot). On December 20 thinned to 3 beet seedlings per pot.

Experimental Design: Randomized complete block; 4 replications.

Data Recorded: Number of seedlings emerging initially; injury ratings to sugarbeets on December 8 and 28; and top weights on January 11.

Herbicides Applied: Postemergence: S6173 at 0.75 lb/A, pyrazon at 2lb/A plus 0.75 lb/A of S6173, and pyrazon at 2 lb/A plus 1.1 lb/A of dalapon. Herbicides were applied at a volume of 60 gal/A broadcast with an endless belt sprayer on November 30.

Stage of Growth at Application: First pair of true leaves 1/2 to 1 inches long and sugarbeets were 1 1/2 to 2 1/4 inches tall.

Reliability of Test: Generally good. Although some seedlings were killed by the herbicide treatments, there was no evidence of damping off in any of the pots.

COMBINING ABILITY OF TRANSGRESSIVE SEGREGATES IN SUGARBEETS

Introduction

The final test of parental components of hybrid sugarbeets (*Beta vulgaris* L.) is their ability to produce, in hybrids, large yields of high quality roots. Advantages of hybrid beet varieties have now been well demonstrated (4). The development and testing of hybrid components (inbred lines, single crosses, and top cross parents) in sugarbeets currently follows quite closely the methods developed in corn, both being primarily cross-pollinated.

There are relatively few resources (personnel and money) available for sugarbeet breeding, and short-cut methods are needed for isolation and identification of superior hybrid components. The purpose of this study was to determine the relative combining ability of individuals which have superior root yield because of additive gene effects, and to evaluate their potential usefulness as parents in hybrid varieties.

Since heterosis is largely an effect of non-additive gene action (dominance and interallelic interactions), it is expected that individuals superior primarily because of the additive effects of their genes would not necessarily have superior specific combining ability. Maximum heterosis requires two lines that differ widely in the gene frequencies at all loci that affect the character and show dominance. Theoretically it should be possible to build up these differences of gene frequency in two lines by selection for high specific and general combining ability. Instead of the differences of gene frequency being produced by the random process of inbreeding, they would be produced by the directed process of selection, an outcome which should be more effective and in some cases more economical. Recurrent selection for specific combining ability and reciprocal recurrent selection provide, in theory at least, this directed process of selection. However, in practice these breeding methods are very difficult to use in sugarbeets. Crossing of 100% in the test crosses is sometimes impossible to achieve, and it is difficult to preserve the parental genotype either by self-pollination (due to self-sterility) or asexual propagation.

Yield per se of inbred lines is not a good indication of the yield of their resulting hybrids. In 1950 Kohls (3) reported that the yielding ability of his F_1 hybrids could not be predicted from parental yields. In 1954 Oldemeyer (5) reported a correlation of 0.37 between inbred root yield and red beet top cross tests.

Breeding studies by Hecker (2) indicate that extreme deviates for root weight from a genetically broad based variety are undoubtedly due primarily to genotype and not to environment. These superior genetic deviates apparently simulated F_1 's (heterozygous at many loci) and the progeny, from particular interpollinations, simulated double crosses. However, phenotypic selections from these simulated double crosses gave progeny which regressed to the mean of the original parental population, possibly because, according to Falconer (1) in a random mating population no dominance effects and only a small part of the epistatic effects are transmitted to the progeny.

This all indicates that the superior root yield of hybrids depends primarily on nonadditive gene action. The material in this study provides the first opportunity for a combining ability test of sugarbeet plants which are known in advance to be superior because of their additive gene effects.

Materials and Methods

Transgressive segregates for high root weight were selected from about 7,000 plants of 54-565 x 52-407, F_2 . The parents of this F_2 population were long term inbreds, having been inbred the equivalent of at least seven generations of selfing. Their origin is unknown except that 52-407 was started from a red segregant of a sugarbeet-garden beet cross in 1938, and 54-565 was started from a yellow F_1 in 1941. Their respective colors have been maintained. 54-565 has low root yield per se but high sucrose, whereas 52-407 has relatively high root weight (for an inbred) and low sucrose content. The 7,000 plants were grown in 24 small units, twelve 20-foot rows per unit, and selections were made within units relative to the mean of each unit. A total of 64 beets were selected for both large root size and high sucrose content. Among them were the seven largest roots, relative to their unit mean. They were halved, and one-half of each was included in an isolation plot with the other 57. The other seven half-beets were put in a separate isolation plot. Also 55 beets were picked at random from the original population of 7,000. These three groups were grown in three isolation plots together with the following cytoplasmic male-sterile inbred lines: 52-305 CMS, NB1 CMS, and NB5 CMS.

The inbred lines, NB1 CMS and NB5 CMS, have a different origin than 52-305 CMS and are resistant to curly top and bolting. NB1 CMS and NB5 CMS have relatively high general combining ability, while that of 52-305 CMS is rather low. In each isolation, seed was harvested from each of these female parents for combining ability testing. The seed from the three male populations resulted from the open-pollination of the 7 best-plant selection, the 64-plant selection, and the 55 random-plant selection. This made a total of 12 different populations to which was added two entries of a check, A56-3. This check was a regionally adapted open-pollinated variety. These 14 entries were grown in 1963 in a randomized complete block design with 30 replications.

Fifteen competitive plants were harvested per plot for a total of 450 plants per entry.

Results

The frequency distributions and means in Table 1 are from a 1959 experiment in which the amount of segregation in 54-565 x 52-407, F_2 was determined and compared with its parents and F_1 . This F_2 had 11 plants out of 320 that were heavier than those in the F_1 or either parent. The other F_2 populations did not show deviates of this nature. Unfortunately the F_1 , 54-407, was not included, but deviates in its F_2 generation did not greatly exceed those of the male parent 52-407. These other two F_2 populations were included in Table 1 to show that transgressive segregation is not the general case. In fact observation of F_2 data over the years indicates that transgressive segregation is the exception. A56-3 is an adapted open-pollinated variety.

In order to establish with some certainty that the transgressive segregants in the F_2 were superior because of their genotype and not merely environmental deviates, the probability of their being environmental deviates was determined. It was necessary to make a log transformation of the data which normalized the F_2 distribution and removed the mean-variance relation. From these transformed distributions it was found that the probability was less than 0.003 that 11 F_2 plants in a population of 320 could be environmental deviates. There was a significant positive relation between the untransformed means and variances of the five nonsegregating populations in Table 1. This is an environmental relationship. Using this regression, the estimated environmental standard error of 54-565 x 52-407, F_2 was 0.013 compared to the obtained standard error of 0.019. This is evidence of the rather large amount of genetic variability in the F_2 . From these data and earlier observations it was evident that there were transgressive segregants occurring in 54-565 x 52-407, F_2 . There is little doubt that most of the seven F_2 plants selected from the population of 7,000 were genetic transgressive segregants.

The 1963 means for weight per root showing the combining ability of the selections and random sample from 54-565 x 52-407, F_2 are listed in Table 2. The 7 best-plant selection, the 64-plant selection, and the 55 random-plant selection did not differ significantly in combining ability using 52-305 CMS and NB1 CMS as testers. However, when using NB5 CMS as the tester, the 7 best plants were significantly lower in combining ability than were the 64-plant selection and 55 random roots. The latter two were not different from each other using NB5 CMS as a tester.

Table 2. Means and standard errors for weight per root in 1963.

Female parent or other	Male parent		
	7 best plants	64 plant selection	55 random plants
	kgs	kgs	kgs
52-305 CMS	0.94 \pm 0.017	0.94 \pm 0.018	0.93 \pm 0.019
NB1 CMS	1.13 \pm 0.022	1.16 \pm 0.022	1.18 \pm 0.026
NB5 CMS	1.10 \pm 0.022	1.19 \pm 0.024	1.23 \pm 0.025
Mean of test crosses	1.06 \pm 0.020	1.10 \pm 0.021	1.11 \pm 0.024
Males open pol- inated	0.77 \pm 0.014	0.69 \pm 0.013	0.72 \pm 0.019
A56-3	1.10 \pm 0.018		

The means of the three test crosses within each of the three male parent groups were not significantly different.

The populations resulting from open pollination of the F_2 plants showed that the 7 best plants resulted in a significant increase of weight per root (7%) over the 55 random plants and an increase of 12% over the 64-plant selection. The difference between the 55 random plants, open-pollinated, and the 64-plant selection open-pollinated, were not significant.

Discussion

The likelihood that there is transgressive segregation in certain F_2 populations indicates that there are potentially identifiable additive (or perhaps epistatic) genetic factors conditioning root size in sugarbeets. Since maximum heterozygosity is achieved in an F_1 , the transgressive segregants in 54-565 x 52-407, F_2 must result from the additive or additive by additive epistatic effects of genes brought together by recombination together with heterosis due to dominance and epistasis. Hence in this particular population, the genes responsible for transgressive segregation for weight per root could be expected to be cumulative in action and comparatively few in number, and to have relatively large effects.

It is not likely that the additive yield genes in these two inbreds are unique; they are probably present in open-pollinated varieties but their effects are indistinguishable from dominance effects, etc. Hence these inbreds are likely to be of little practical value, but they do provide evidence that in beets there are genes with additive effects for root size. This becomes more understandable when the mean and distribution of A56-3 are compared with the other populations in Table 1. The effects of the genes in 54-565 x 52-407, F_2 are dwarfed by genetic combinations which apparently occur in A56-3. The relatively high yield of the parental inbred 52-407 indicates that additive genes or additive by additive epistatic combinations have been accumulated and fixed by inbreeding. The inbred 54-565 must then possess other genes with additive effects, so that in the F_2 superior recombinations occur.

The main object of the experiment, however, was to test these genotypes for combining ability to determine whether these transgressive segregates had different combining ability than their random sibs.

As previously noted in Table 2, the 7 best plants had combining ability similar to the 64-plant selection and the random sample for two of the three testers..

The 7 best plants were not significantly different from the other two populations, when using the mean of the three tester inbreds as a determinant of general combining ability. There was a tendency for the 7 best-plant selection to have lower combining ability than both the 64-plant selection and the random sample. However, the 7 best-plants open-pollinated were significantly heavier than the open-pollinated random sample. The 64-plant selection was not significantly different than the random sample. The superiority of the 7 best-plants open-pollinated is further evidence of genes with additive effects.

Heterosis for root yield is present in all three test crosses with all three male parents. Since the individuals in the test crosses received half their genes from the male parents, why some influence of the additive genes from the 7 best plants was not evident in their test cross progeny has several possible explanations, the following being most likely. The difference due to the additive genes in the 7 best-plants (as shown by the open-pollinated population) is small relative to the difference due to heterosis (as shown by the three test crosses). Since there were fewer opportunities for heterotic combinations from the 7-best plants, relative to the 64 and 55 plant selections, the effect of the additive genes from the 7 best plants could have been negated by the decreased heterosis relative to the 64 and 55 plant selections.

Selection for the 64 plants was apparently not sufficiently intense to exclude environmental deviates.

It can be concluded that some of the 7 best plants were transgressive segregates, primarily because they had a gene or genes with additive effects or additive epistatic effects. The contribution of these genes isolated by selection was not apparent in the combining ability tests since their contribution was small relative to the heterosis effects of other loci. From the material studied it appears that the contribution of individual plants (superior because of additive genes) to better combining ability is only additive and may be overwhelmed and obscured by heterosis effects of other loci.

Summary

Transgressive segregation in an F_2 generation for increased root size in sugarbeets (Beta vulgaris L.) indicates the presence of genes with additive effects which condition this character. These genes are probably not unique to the inbred parents of this F_2 . Seven interpollinated transgressive segregants produced heavier roots than an interpollinated random sample from the F_2 . However, the combining ability of these seven transgressive segregants was not different from that of an F_2 random sample, or a less intensely selected group of 64 plants. This study indicates that individuals superior because of additive genes may have no better combining ability than a random sample from their parent population.

Acknowledgment

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GENETIC RELATIONS OF CERTAIN ROOT AND LEAF CHARACTERS IN SUGARBEETS

Introduction

In 1965 a field experiment was conducted to study the relationships of thirteen different characters in sugarbeets. Initial interest was in the relation of 3-hydroxytyramine with root yield and sucrose on an individual plant basis. These characters were discussed in the Sugarbeet Research, 1966 Report (3). Analyses of all plant materials have now been completed and will be reported herein.

It has been determined that the quantity of 3-hydroxytyramine in a plant is greatly affected by both stage of growth and environment (4, 5). Hence the heritability of this character is not consistent although in most heterogeneous populations there is sufficient genetic variability so that genetic shift by selection should be possible. This phenolic compound is of interest because it has a general relationship with *Cercospora* leaf spot resistance. Its specific relationship is currently being studied. The other characters in this study were measured in an attempt to detect possible relationships that would provide clues for new avenues of research in the study of the biochemical and physiological nature of *Cercospora* resistance. Also the relationships of certain of these chemical characters might be of considerable interest in basic quality studies. Certain of the characters in this study have never before been measured in sugarbeets and should be of interest from that standpoint alone. Interest in the divalent metals i.e., copper, cobalt, calcium, and magnesium, in leaves was aroused because of evidence that one or more types of divalent ions may be involved as catalysts or coenzymes in the oxidation of 3-hydroxytyramine (6). This all relates to the findings of Harrison et al. (1) that in vitro *Cercospora beticola* does not grow on a culture which contains oxidized 3-hydroxytyramine.

Materials & Methods

The following sugarbeet populations were used:

1. FC 901 heterogeneous; self-fertile; multigerm; moderate leaf spot resistance and high curly top resistance; a line from a backcrossing program where US 201 served as the nonrecurrent parent and various CTR lines served as recurrent parents; developed by J. O. Gaskill for use as a pollinator in hybrid varieties.

2. [52-305CMS X (52-430 X 52-407)F₁]OP - first open-pollinated generation of a 3-way hybrid; moderate leaf spot resistance; 52-305CMS is a high 3-hydroxytyramine inbred.
3. A56-3 a multigerm open-pollinated commercial variety; moderate leaf spot resistance.
4. (52-305CMS X 52-408)F₁ - F₁ hybrid; moderate leaf spot resistance.

Populations 2 and 4 are half sibs, hence, quite closely related. The other populations should be genetically different in many respects although they would not be considered to have great genetic diversity.

The following characters were measured and for individual plant analyses were transformed as indicated:

1. Weight per root (kgs), square root
2. Percent sucrose
3. Apparent thin juice purity
4. Net recoverable sugar per root (kgs), square root
5. 3-hydroxytyramine (mg/100 gm frozen leaf), square root
6. Leaf copper (mg/100 gm dried leaf), log₁₀
7. Leaf Cobalt (mg/100 gm dried leaf)
8. Leaf calcium (mg/100 gm dried leaf), square root
9. Leaf magnesium (mg/100 gm dried leaf), log₁₀
10. Thin juice potassium (mg/100 ml)
11. Thin juice sodium (mg/100 ml)
12. Thin juice total nitrogen (mg/100 ml)
13. Thin juice copper (mg/100 ml)

Net recoverable sugar was calculated from a formula standard with the Great Western Sugar Company in which sucrose and purity are input variables and molasses purity and loss are constant. All thin juice chemical characters are adjusted to a refractive dry substance of 10.

The experiment was grown under irrigation at the Colorado State University Agronomy Research Center. The design was a randomized complete block with 38 replications and single row plots with

a common competitor between each plot row. Twelve competitive plants were harvested from each plot and individually analysed for root weight, sucrose, recoverable sugar, 3-hydroxytyramine, and the leaf characters copper, cobalt, calcium, and magnesium. Determinations of thin juice purity, potassium, sodium, nitrogen, and copper were made on a plot basis from a composite sample of the 12 roots in each plot. The means, analyses of variance, and total correlations in this report were calculated from plot means for those characters determined on individual plants so that the measurements correspond with those characters done on a plot basis. The variance components, heritability ratios, and genetic correlations were calculated for those characters determined on individual plants. For analyses of plot means no transformation was necessary since according to the central limit theorem the distribution of means tends to normality. For those analyses on individual plant data certain scale changes were made in order to achieve more nearly homogeneous variances and normal distributions on which variance components and genetic correlations are predicated. The transformations used are noted in the tables wherever transformed data were used in the analysis. These transformations were based on empirical tests of different scales using third and fourth moments about the mean, and regressions of variances on means.

Samples for leaf analysis were collected the first week of August, about 8 weeks prior to harvest. Previous studies indicated that 3-hydroxytyramine was near its maximum at this growth stage (5). The thin juice was a product of the phosphoric acid method [Brown & Serro (1954) as modified by Carruthers & Oldfield (1961)].

Changes of scale to achieve approximate normality for individual plant data are essential for a valid study. However, scale changes should be biologically reasonable and not simply a mathematical manipulation. Arguments can be presented for the logic of each of the transformations chosen. The analyses involving plot means did not require scale changes as sample means tend to be distributed normally even if the population is anormal.

Results & Discussion

The means for all populations for all characters are presented in Table 1. Population means for certain characters differ considerably. From the analyses of variance in Table 2 we see that there are significant differences among populations for weight per root, percent sucrose, purity, recoverable sugar, 3-hydroxytyramine, calcium, magnesium, sodium, and total nitrogen. The other four characters were not significantly different from one population to another. Some reference will be made to the means in later discussions.

Total genetic variances and heritability ratios are estimated in Table 3. In these estimates the total within plot variance of the F_1 is used as an estimate of the environmental variance since all plants in this population have the same genotype. Variation due to replications has been removed in calculation of the total within plot variances. This estimate of the environmental variance is subtracted from the other total within plot variances to estimate the total genetic variances. These genetic variances include variation due to additive, dominance, and epistatic gene effects. The heritability ratios (h^2) are ratios of total within plot variance to total genetic variance. As such they are defined as broad sense heritabilities. This type heritability ratio is subject to some criticism because it does not present a true picture of the variability which can be capitalized on through selection. For example, if the heritability ratio is high it indicates that there is considerable genetic segregation, implying that it should be possible to select individuals. However if the genetic variance was primarily due to dominance and/or epistasis, progress by selection would be very slight because no dominance effects and only a small portion of the epistatic effects are transmitted to the progeny. In previous studies, Hecker (2), the genetic variance for root weight was largely due to dominance and epistatic gene effects (non-additive genetic variance), while for sucrose over half of the genetic variance was due to additive gene effects. The genetic variances for the other characters in Table 3 have never been partitioned. The design of this experiment does not permit such a partition of the total genetic variance. None the less these broad sense heritability estimates do provide useful information about these characters and afford comparisons between populations.

The heritability estimates for sucrose are quite high compared with past estimates. However, the amount of genetic variance in a population is a function of the genotypes in the population and the genotype by environment interactions. In the case of root weight, sucrose and recoverable sugar the 3-way hybrid has the lowest

Table 1. Means and standard errors for all characters (on arithmetic scale) in the 1965 population genetic studies.

Character	<u>Population</u>			
	1 FC 901	2 52-305CMS X (52-430X52-407)F ₁	3 A56-3	4 52-305CMS X 52-408,F ₁
Weight (kg/root)	0.516 [±] 0.013	0.417 [±] 0.009	0.689 [±] 0.014	0.565 [±] 0.014
Sucrose (%)	14.27 [±] 0.148	15.37 [±] 0.169	15.43 [±] 0.176	15.28 [±] 0.151
Thin juice pur- ity (%)	94.09 [±] 0.340	92.71 [±] 0.356	92.58 [±] 0.395	92.90 [±] 0.698
Recov. sugar (kg/root)	0.065 [±] 0.002	0.054 [±] 0.001	0.089 [±] 0.002	0.073 [±] 0.002
3-hydroxytyramine (mg/100gm frozen leaf)	27.85 [±] 1.819	103.19 [±] 4.117	34.76 [±] 2.647	63.31 [±] 3.485
Leaf copper (mg/100 gm)	1.80 [±] 1.158	1.79 [±] 0.589	1.78 [±] 0.488	1.71 [±] 0.627
Leaf cobalt (mg/100 gm)	1.09 [±] 0.031	1.18 [±] 0.044	1.13 [±] 0.042	1.11 [±] 0.031
Leaf calcium (mg/100 gm)	470.07 [±] 18.57	439.60 [±] 20.93	520.09 [±] 22.62	475.70 [±] 20.85
Leaf magnesium (mg/100 gm)	374.80 [±] 16.23	427.79 [±] 17.18	464.96 [±] 17.92	486.11 [±] 21.55
Thin juice potassium (mg/100 ml)	83.92 [±] 15.70	84.21 [±] 3.193	80.82 [±] 3.152	97.74 [±] 3.892
Thin juice sodium (mg/100 ml)	43.75 [±] 2.499	33.18 [±] 2.345	43.38 [±] 3.109	24.26 [±] 1.480
Thin juice nitrogen (mg/100 ml)	43.95 [±] 2.745	49.40 [±] 3.308	53.51 [±] 3.247	47.11 [±] 3.081
Thin juice copper (mg/100 ml)	0.195 [±] 0.013	0.199 [±] 0.012	0.208 [±] 0.014	0.197 [±] 0.011

Table 2. Mean squares in the analyses of variance of 13 characters, calculated from plot determinations and plot means.

Source of Variation	DF	Weight per root	Percent Sucrose	T. J. Purity	Rec. Sugar	3-hydroxy-tyramine	Leaf copper	Leaf Cobalt
Population	3	0.48557134**	11.418099**	18.27001*	0.00836361**	44548.550**	6.51509	0.0517613
Replication	37	0.00926590*	2.810776**	14.07769**	0.00023630**	745.888**	47.62815**	0.1074925**
P X R	111	0.00514298	0.381995	6.51961	0.00012115	250.521	13.49062	0.0351111

Source of Variation	DF	Leaf Calcium	Leaf Magnesium	T. J. Potassium	T. J. Sodium	T. J. Nitrogen	T. J. Copper
Population	3	41841.39**	90438.21**	2158.78	3296.3750**	615.7220**	0.00117456
Replication	37	52984.82**	35912.12**	3588.38	631.1144**	1181.5453**	0.01642155**
P X R	111	4583.66	5265.24	2370.87	88.5200	93.8885	0.00280429

Table 3. Total within plot variances, genetic variances, and broad sense heritability ratios (h^2) calculated from individual plant data (456 plants per population).

Character	Popu- lation	Total within plot variance	Total genetic variance	h^2
$\sqrt{\text{Wt}/\text{root}}$	1	0.0378367	0.0225003**	0.595
	2	0.0233581	0.0080217**	0.343
	3	0.0429196	0.0275832**	0.643
	4	0.0153364		
% Sucrose	1	2.16788	1.662413**	0.767
	2	1.02761	0.522143**	0.508
	3	1.62600	1.120533**	0.689
	4	0.505467		
$\sqrt{\text{Rec. Sug.}}$	1	0.00501625	0.00297960**	0.594
	2	0.00301897	0.00098232**	0.325
	3	0.00536655	0.00332990**	0.620
	4	0.00203665		
$\sqrt{3\text{-hydroxytyramine}}$	1	4.93946	2.36375**	0.479
	2	7.35885	4.78314**	0.650
	3	4.98486	2.40915**	0.483
	4	2.57571		
Log_{10} leaf copper	1	0.0130631	0.00467581**	0.358
	2	0.0155041	0.00711681**	0.459
	3	0.00953953	0.00115224	0.121
	4	0.00838729		
Cobalt	1	0.0407232	0.0042373	0.104
	2	0.255311	0.2188251**	0.857
	3	0.247724	0.2112381**	0.853
	4	0.0364859		
$\sqrt{\text{Calcium}}$	1	19.1103	9.73798**	0.510
	2	13.4356	4.06328**	0.302
	3	19.9926	10.62028**	0.531
	4	9.37232		
Log_{10} magnesium	1	0.0305564	0.0093496**	0.306
	2	0.0281690	0.0069622**	0.247
	3	0.0311119	0.0099051**	0.318
	4	0.0212068		

** indicates that the genetic variance is significantly (1% level) greater than zero; hence, the corresponding heritability ratio must be significantly greater than zero.

heritability, and this would be expected since the gametes from the male parent in this population were homogeneous. The heritability of recoverable sugar follows that of root weight quite closely since recoverable sugar is determined primarily by root weight. 3-hydroxytyramine is relatively heritable. Leaf copper and magnesium tend to be lower in heritability. Hence the genes conditioning uptake and/or accumulation of these metals may have small effects, or may be very susceptible to environmental effects. Copper and magnesium are not important impurity components so they are likely to be of little interest unless they should be found to have some special function in disease resistance, growth, sucrose synthesis, etc.

Cobalt is highly heritable in the 3-way hybrid and A56-3, but not so in FC 901. This is not unreasonable; FC 901 may be near homozygous for cobalt assimilation and/or accumulation. The great difference in these heritability estimates is a indication that the quantity of cobalt in the leaves may be conditioned by one or a few genes with large effects. The absence of differences between means in Table 1 merely indicates that the net effect of the segregating genes in populations 2 and 3 is the same as the effect of the nearly homozygous genes in FC 901.

Calcium is not an important impurity component unless calcium chloride or calcium sulfate are present in fairly high concentrations. The relatively high heritability estimates for calcium in this study means that there is considerable genetic segregation for calcium in the leaves.

The correlations in Table 4 are total correlations and genetic correlations (for the three segregating populations) calculated from individual plant data. The total correlations include relationships due to both environment and genotype. The genetic correlations represent the relation of two characters after the effect of environment has been removed. The total and genetic correlations of root weight vs. recoverable sugar and calcium vs. magnesium are significant and consistent for all populations. The unexpected feature of the correlations is the inconsistency of the genetic correlations. This could be interpreted to mean that the genotypes of FC 901, 3-way hybrid, and A56-3 are all different for sucrose, 3-hydroxytyramine, leaf copper, and leaf cobalt.

The correlations in Table 5 were calculated from the 38 plot means or plot determinations. Within plot covariation cannot be a factor here but some effect of genetic covariation is still expected to be present. These correlations are directly related to the

Table 4. Continued

Population and Character	Character						
	2	3	4	5	6	7	8
A56-3							
1 $\sqrt{\text{Wt}/\text{root}}$	-0.115*	0.163**	-0.033	0.959**	-0.008	-0.061	-0.018
	-0.140*	0.210**	-0.006	0.982**	-0.025	-0.063	0.002
2 % Sucrose		-0.012	-0.042	0.148**	-0.043	-0.028	-0.131**
		0.093	0.230**	0.039	-0.038	0.019	0.030
3 $\sqrt{3\text{-OH-tyramine}}$			0.020	0.158**	0.098*	-0.217**	-0.180**
			-0.011	0.222**	-0.020	0.050	0.033
4 Log_{10} Leaf copper				-0.056	0.130**	-0.145**	0.128**
				0.035	-0.036	-0.158*	0.441**
5 $\sqrt{\text{Rec. Sugar}}$					-0.021	-0.070	-0.062
					-0.032	-0.059	0.008
6 Cobalt						-0.062	0.072
						0.041	0.059
7 $\sqrt{\text{Calcium}}$							0.702**
							0.700**
8 Log_{10} Magnesium							1.000
							1.000

Table 4. Continued

Population and Character		Character					
F ₁ hybrid (total correlations)	2	3	4	5	6	7	8
1 $\sqrt{\text{Wt./root}}$	0.008	0.044	-0.140**	0.895**	0.077	-0.031	0.050
2 % Sucrose		-0.079	-0.196**	0.229**	0.033	0.156**	0.053
3 $\sqrt{3\text{-OH-tyramine}}$			0.106*	0.057	0.071	-0.351**	-0.319**
4 Log ₁₀ Leaf copper				-0.149**	0.204**	-0.191**	-0.082
5 $\sqrt{\text{Rec. sugar}}$					0.147**	-0.045	0.007
6 Cobalt						-0.126*	0.047
7 $\sqrt{\text{Calcium}}$							0.754**
8 Log ₁₀ Magnesium							1.000

226 df for testing genetic r.

454 df for testing total r.

Table 5. Simple correlation coefficients within populations for all characters, calculated from plot determinations and means.

Population and Character													
FC 901	2	3	4	5	6	7	8	9	10	11	12	13	
1 Wt/rt	0.089	-0.143	0.826**	0.123	-0.125	-0.036	-0.163	-0.110	0.101	0.109	0.291	0.019	
2 % Sucrose		0.769**	0.607**	0.129	0.011	0.083	0.151	0.161	-0.143	-0.770**	-0.636**	-0.366*	
3 T. J. Purity			0.387	-0.060	0.121	0.090	0.235	0.077	-0.031	-0.856**	-0.824**	-0.433**	
4 Rec. Sugar				0.143	-0.070	0.017	-0.025	-0.018	0.005	-0.373*	-0.200	-0.212	
5 3-OH-tyramine					0.003	0.341*	-0.466**	-0.135	-0.092	0.102	0.073	0.021	
6 Leaf Cu						0.002	-0.023	-0.155	0.034	-0.139	-0.092	-0.308	
7 Leaf Co							-0.155	0.030	-0.051	0.092	-0.027	-0.244	
8 Leaf Ca								0.563**	-0.007	-0.174	-0.174	0.116	
9 Leaf Mg									-0.029	-0.003	-0.010	0.221	
10 T. J. K										0.154	0.078	0.132	
11 T. J. Na											0.741**	0.537**	
12 T. J. N												0.312	
13 T. J. Cu												1.000	

3-way hybrid	2	3	4	5	6	7	8	9	10	11	12	13	
1 Wt/rt	-0.169	-0.455**	0.665**	0.032	-0.100	0.076	-0.053	0.196	0.539**	0.338**	0.539**	-0.027	
2 % Sucrose		0.602**	0.563**	-0.257	0.009	0.021	0.365*	0.126	-0.560**	-0.819**	-0.685**	-0.327*	
3 T. J. Purity			0.250	-0.195	0.248	0.037	0.033	-0.200	-0.844**	-0.844**	-0.778**	-0.505**	
4 Rec. sugar				-0.130	0.008	0.083	0.134	0.156	-0.084	-0.417*	-0.149	-0.365*	
5 3-OH-tyramine					0.033	-0.182	-0.565**	-0.496**	0.296	0.313	0.253	0.046	
6 Leaf Cu						0.009	-0.192	-0.179	-0.150	-0.055	-0.067	-0.166	
7 Leaf Co							0.050	0.310	0.058	0.028	0.054	0.069	
8 Leaf Ca								0.809**	-0.034	-0.308	-0.290	0.127	
9 Leaf Mg									0.294	-0.043	0.035	0.183	
10 T. J. K										0.771**	0.818**	0.441**	
11 T. J. Na											0.811**	0.524**	
12 T. J. N												0.175	
13 T. J. Cu												1.000	

total correlations in Table 4, but cannot be expected to be the same since the within plot covariation is not included and the data were on the arithmetic scale. Again the most significant thing about these correlations is, first, the inconsistency and, second, the absence of significant relationships in many cases. The only correlations consistent across all populations are 3-hydroxytyramine vs. leaf calcium (neg.), leaf calcium vs. leaf magnesium (pos.), sucrose vs. thin juice sodium (neg.), sucrose vs. thin juice nitrogen (neg.), and nitrogen vs. sodium (pos.). Most of these relations were to be expected. The correlation of 3-hydroxytyramine is negative with calcium and tends to be negative with magnesium but positive with cobalt. It has no correlation with leaf copper. Hence, 3-hydroxytyramine does not appear to be functionally related to divalent metallic ions as a class but it may still be related specifically to certain ones. Calcium would appear to be of most interest in this regard and may be worthy of further study. There were significant population mean differences for both 3-hydroxytyramine and calcium.

Correlations between leaf and thin juice characters could be weakened by the fact that the leaves were harvested the first week in August (time of maximum 3-hydroxytyramine content) while the roots were harvested about 2 months later.

In general the data on the thin juice impurity components tend to support what is already known about their relationships. The metal determinations in the leaves show that calcium and cobalt would most likely be amenable to selection, but information about them is not likely to be of much value in studies on root weight or sucrose. With respect to 3-hydroxytyramine, calcium is the only character of real interest. A physiological explanation of this association is not readily apparent.

Although the populations in this experiment were genetically different they do not have great genetic diversity. Future studies of this nature should include more genetically diverse populations and a greater range in *Cercospora* resistance. The range in 3-hydroxytyramine content was quite large but as it has been pointed out in earlier studies (3) the quantity of this phenolic compound cannot be used as a direct measure of leaf spot resistance even though there is a general relationship between them.

Summary

This experiment was a study of genetic variances and correlations and a search for associations among divalent metals in the leaves (copper, cobalt, calcium, and magnesium), 3-hydroxytyramine in the leaves, impurity components in the thin juice (total nitrogen, sodium, potassium, and copper), and the yield characters weight per root, sucrose percentage, apparent thin juice purity, and recoverable sugar.

The experiment consisted of four populations in 38 replications from which individual plant data (456 plants per population) were taken for 8 of the 13 characters in the study. Plot determinations were made for the other five characters.

Genetic variances and broad sense heritability ratios were estimated for eight characters. Considerable genetic variability is present for root weight, percentage sucrose, recoverable sugar, and 3-hydroxytyramine, indicating the genetic plasticity of these characters and the potential for genetic shift. However, the genetic variance could not be partitioned into additive (heritable) and non-additive (non-heritable) components. The quantity of copper and magnesium in the leaves tends to be lower in heritability; however, for the present these characters are not known to be closely related to any characters of real interest. The heritability of leaf cobalt was very high for two populations and very low for one, indicating that one or a few genes with large effects may condition this character in these particular populations. No important relationships with cobalt have been determined. Calcium has a rather high heritability and is an important impurity component when large quantities of calcium sulfate and calcium chloride are present.

The genetic correlations are in general very weak and inconsistent. The only consistent genetic correlations among the eight characters compared are root weight vs. recoverable sugar and calcium vs. magnesium. The correlations calculated from plot determinations are also weak and inconsistent. The relationship of calcium to 3-hydroxytyramine is consistently negative and worthy of further study. Divalent metallic ions as a class do not appear to be functionally related to 3-hydroxytyramine.

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CERCOSPORA LEAF SPOT RESISTANCE AND ITS RELATION TO FIFTEEN YIELD AND CHEMICAL CHARACTERS

This is a complete report of a 1966 experiment relating inherent leaf spot resistance in sugarbeets with 15 yield and chemical characters. The purpose of this study was to determine if there was any relationship between 3-hydroxytyramine (1) production, yield characters, and several ions or molecules which exist in the beet plant. Possible interaction of ion concentration in relation to fertility level and 3-hydroxytyramine production was of primary interest. Populations of known resistance to leaf spot may have unique ion relationships which do not occur in susceptible populations.

A previous experiment indicated that thin juice impurity components are all positively correlated with each other and negatively correlated with sucrose and purity (2). Leaf chemical characters were not so highly and consistently correlated. The relationship of 3-hydroxytyramine to weight and sucrose has not been close in experiments (1963-64-65 data).

Previous studies (3) have shown that 3-hydroxytyramine in beet leaves, when oxidized, is toxic to Cercospora beticola Sacc. grown in pure culture. Copper is the central atom in polyphenoloxidase, the enzyme which oxidizes 3-hydroxytyramine. Copper and the enzyme have been shown to be non-limiting in the formation or accumulation of 3-hydroxytyramine (2).

Materials and Methods

The experiment consisted of nine populations, two copper treatments (0 and 100 lbs. per acre copper sulfate side dressed on each side of the plot row after thinning), three actual nitrogen fertility levels (0, 100, and 250 lbs. per acre applied as ammonium nitrate) with seven replications. The design was a split-split plot. The two copper treatments were randomized within replications, the three nitrogen treatments were randomized within copper treatments, and the nine populations were randomized within nitrogen treatments.

The plots consisted of single rows, 21 feet long, with a common competitor between rows. The leaf samples were taken from the same roots which were used for character determinations.

Analyses were made on a plot basis. The characters studied and determination measurements were as follows; weight in kilograms, percent sucrose, percent apparent thin juice purity, 3-hydroxytyramine (mg/100 g frozen leaf), and copper (mg/100 g dried leaf). Thin juice determinations (mg/100 ml thin juice equated to a refractive dry substance of 10) were made for sodium, potassium, copper, cobalt, calcium, magnesium, iron, and total nitrogen. Pressed juice conductivity was also measured.

The populations were:

- | | |
|--|--|
| 1. US 201 | Highly leaf spot resistant, heterogeneous. |
| 2. GWI-29 | Leaf spot resistant, inbred. |
| 3. SP 5822-0 | Highly leaf spot resistant, heterogeneous. |
| 4. GW 359-52R | Moderately leaf spot resistant, heterogeneous. |
| 5. R & G Pioneer | Leaf spot susceptible, heterogeneous. |
| 6. 52-334 | Very leaf spot susceptible, inbred. |
| 7. 52-305 CMS X 52-407, F ₁ | High 3-hydroxytyramine, homogeneous hybrid. |
| 8. 52-305 CMS | Inbred. |
| 9. 52-407 | Inbred. |

The populations were planted April 11, 1966, and were harvested October 3, 1966.

Results and Discussion

An analysis of variance for all characters in relation to three treatments shows that the response to the copper treatment was non-significant for all characters (Table 1). This would indicate that the copper sulfate which was side-dressed into the soil was probably not available to the plant or was not taken up by the plants even though abundant in the soil. Response to nitrogen was significant for sucrose, conductivity, purity, recoverable sugar, thin juice copper, potassium, sodium, nitrogen, calcium, magnesium and iron. Population differences were significant for all characters. The nitrogen by copper interaction was significant for 3-hydroxytyramine, sodium and, at the ten percent level, for iron. There was no population by copper interaction for any of the characters. The population by nitrogen interaction was significant for weight, sucrose, purity, recoverable sugar, 3-hydroxytyramine, and thin juice copper, potassium, sodium, nitrogen and iron. The population by nitrogen by copper interaction was significant for 3-hydroxytyramine and leaf copper.

An analysis of variance, ignoring the copper treatment, shows the same results, in regard to ten of the characters, as does the over all analysis with the exception of significant replication effects occurring for cobalt, calcium, magnesium, iron, and leaf copper (Table 2).

Table 1. Analysis of variance on fifteen characters in relation to three treatments. Split-split plot design: 7 replications, 2 copper treatments randomized within replications, 3 nitrogen treatments randomized within copper treatments, and 9 populations randomized within nitrogen treatments.

Mean Squares for Characters										
Source	Degrees Freedom	Weight	% Sucrose	Conductivity	Purity	Rec. Sugar	3-OH tyramine	Leaf Cu	Thin Juice Cu	
Replications	6	10.23	1.20	.4284	45.70	.2912	2,484.20	2.9642		.2582
Copper	1	14.90	1.16	.0004	38.39	.5047	7,369.21	.9410		.1230
Error (a)	6	7.27	2.46	.1018	19.76	.1622	1,816.89	.8423		.3062
Nitrogen	2	2.61	194.42**	19.1035**	859.74*	2.6883*	2,573.73	.6635		4.6259**
N X Cu	2	10.30	3.22	.0938	2.31	.2818	4,904.84*	1.2682		.4247
Error (b)	24	3.52	1.25	.1058	5.85	.0865	1,068.76	.4936		.2364
Populations	8	472.75**	27.50**	1.4001**	69.73**	10.1521**	25,418.02**	2.6725**		3.4001**
P X Cu	8	2.22	1.22	.0626	6.39	.0841	98.30	.0414		.0348
P X N	16	3.14*	1.30*	.0540	9.97*	.0823*	516.42**	.1557		.8399**
P X N X Cu	16	1.03	.61	.0581	6.98	.0288	374.77*	.2678*		.1431
Error (c)	288	1.76	.63	.0539	4.64	.0457	166.91	.1351		.1250

Source	Degrees Freedom	Potassium	Sodium	Nitrogen	Cobalt	Calcium	Magnesium	Iron	
Replications	6	1,275.16*	288.97	617.85	1.4085	530,561.09	174,083.37	695.19	
Copper	1	106.74	292.39	3,474.50	0.0109	2,149.58	192,273.48	51.94	
Error (a)	6	258.53	574.43	2,211.80	0.6890	217,262.79	324,921.33	161.44	
Nitrogen	2	41,672.42**	30,376.43**	71,115.83**	0.1910	857,217.77**	2,759,444.54**	2,632.97**	10%
N X Cu	2	127.59	1,400.40**	699.49	0.3376	18,160.92	70,642.14	371.94	
Error (b)	24	245.83	213.52	763.35	0.2441	58,626.88	83,474.96	112.00	
Populations	8	13,839.01**	3,568.68**	14,812.34**	0.3437*	777,672.73**	873,450.09**	1,159.50**	
P X Cu	8	161.19	109.73	129.50	0.2105	54,817.97	43,903.58	26.56	
P X N	16	640.70**	565.48**	1,005.00**	0.1796	83,447.39	58,426.23	183.36**	
P X N X Cu	16	92.69	80.09	241.72	0.1615	52,633.87	52,497.15	67.40	
Error (c)	288	152.83	90.24	256.61	0.1541	51,125.04	37,962.39	63.65	

Table 2. Mean squares in the analysis of variance of 10 characters, ignoring copper split.

Character		Cobalt	Calcium	Magnesium	Iron
Source	DF				
Replicate	14	0.9237	428,824.8435**	372,048.9972**	430.6022*
Nitrogen	2	0.3904	917,616.7851**	2,380,795.4107**	3,699.8206**
Error (a)	28	0.2679	54,787.3130	81,911.1506	185.6831
Population	8	0.3545*	800,139.3256**	985,222.9621**	1,376.5157**
P X N	16	0.1802	78,386.7012	56,779.2244	241.1299**
Error (b)	336	0.1522	50,376.5784	38,146.4164	65.5280

Character		Leaf Copper	Thin Juice Copper	Potassium	Sodium	Nitrogen
Source	DF					
Replicate	14	1.6992**	0.2507	664.9685	485.4697	1,467.8495
Nitrogen	2	0.6647	4.4417**	42,174.1478**	32,704.1700**	75,847.0589**
Error (a)	28	0.5234	0.2478	331.2060	283.8629	740.9437
Population	8	2.7918**	3.5305**	14,067.9216**	3,780.2220**	15,480.2767**
P X N	16	0.1578	0.8347**	766.1407**	648.2266**	1,019.7475**
Error (b)	336	0.1342	0.1204	168.2040	93.7065	246.0106

Means for leaf copper within nine populations and three nitrogen treatments are shown in Table 3. There were no significant differences between copper treatments within populations. The analysis of variance (Table 1) shows a significant effect of the variance sources, nitrogen by copper, populations, population by nitrogen, and population by nitrogen by copper on the level of 3-hydroxytyramine. The means in Table 3 show that there are differences between populations in the amount of leaf copper present. This is also the case with thin juice copper (Table 4). The leaf copper content with zero copper treatment at the three nitrogen levels decreased as nitrogen treatment increased in all populations except eight (Table 6). The high copper treatment showed an increase in 3-hydroxytyramine as nitrogen treatment increased for all but populations three and six which decreased and four and five which increased at the 100 pound treatment and decreased at the 250 pound treatment (Table 6). The thin juice copper at the 100 pound nitrogen treatment showed some differences between populations as to decreases or increases in copper content, however, all populations (when looking at the means across both copper treatments) increased in thin juice copper content at the 250 pound nitrogen treatment over the zero nitrogen treatment (Table 5). The leaf copper within the 100 pound copper treatment with the exception of populations 4 and 6 increased quantitatively over the zero nitrogen treatment and then all populations decreased with increasing nitrogen to 250 pounds per acre. The thin juice copper content (ignoring copper treatment), with the exception of population one at the 100 pound nitrogen treatment, increased over all populations from zero to 100 to 250 pounds of nitrogen. This data then indicates, for these populations, that in general as nitrogen treatment increases leaf copper content will decrease and root copper in thin juice will increase. This phenomenon seems to be a function which happens in all populations. Table 7 shows that the ratio of leaf copper to thin juice copper is lowered as nitrogen application increases. There is little difference in the ratio within copper treatments over all nitrogen treatments; however, there was a general decrease of the ratio with higher applications. Nitrogen then at higher levels of application seems to inhibit the transport of copper to the leaves. Means for 3-hydroxytyramine by population within the three nitrogen treatments show that as nitrogen application increases, 3-hydroxytyramine content in leaves decreases (Table 5). When mean 3-hydroxytyramine is compared to mean leaf copper and mean root copper, there is a general indication that nitrogen may lower 3-hydroxytyramine through its effect on copper translocation from the root to the leaves. This would mean that copper has something to do with 3-hydroxytyramine formation. Table 5 shows that high copper level consistently lowers 3-hydroxytyramine content. However, statistically this is not a significant difference (Table 1). Past experiments have shown that there is a negative relationship between polyphenoloxidase and 3-hydroxytyramine. Polyphenoloxidase data were not taken on this experiment but since copper is the central atom in this enzyme, polyphenoloxidase may not only oxidize 3-hydroxytyramine but also help in its synthesis. Since it is not known whether the enzyme

Table 3. Means for leaf copper within 9 populations and 3 nitrogen treatments.

Popu- lation	0 lbs. Cu		100 lbs. Cu		Cu 1 + Cu 2		N1 + N2 + N3		Grand Total			
	N treatment		N treatment		N treatment		Copper Treatment					
	0 lbs.	100 lbs.	0 lbs.	100 lbs.	0 lbs.	100 lbs.	0 lbs.	100lbs.				
1	1.924	2.007	1.807	1.734	1.968	1.994	1.823	1.986	1.907	1.913	1.898	1.905
2	1.814	2.103	1.800	1.771	2.052	1.838	1.791	2.076	1.820	1.906	1.887	1.896
3	2.650	2.160	2.060	2.011	2.252	2.159	2.309	2.209	2.113	2.290	2.141	2.210
4	2.579	2.617	2.164	2.486	2.409	2.112	2.529	2.506	2.137	2.453	2.336	2.391
5	2.793	2.107	2.407	2.140	2.554	2.244	2.445	2.345	2.320	2.436	2.313	2.370
6	2.124	2.217	2.064	2.100	1.999	1.856	2.111	2.101	1.953	2.135	1.985	2.055
7	2.324	1.903	1.860	1.666	2.234	1.921	1.973	2.079	1.893	2.029	1.940	1.982
8	1.721	1.643	1.829	1.656	1.715	1.825	1.687	1.681	1.827	1.731	1.732	1.732
9	2.086	1.793	1.557	1.485	1.805	1.626	1.765	1.799	1.594	1.812	1.639	1.720
Average	2.224	2.061	1.950	1.894	2.110	1.953	2.048	2.086	1.952	2.078	1.986	

Table 4. Means for thin juice copper within 9 populations and 3 nitrogen treatments;

Popu- lation	0 lbs. Cu			100 lbs. Cu			Cu 1 + Cu 2			N1 + N2 + N3 Copper Treatment			Grand Total
	N Treatment			N Treatment			N Treatment			Treatment			
	0 lbs.	100 lbs.	250 lbs.	0 lbs.	100 lbs.	250 lbs.	0 lbs.	100 lbs.	250 lbs.	0 lbs.	100 lbs.	250 lbs.	
1	0.063	0.048	0.077	0.065	0.057	0.084	0.064	0.053	0.081	0.063	0.069	0.066	
2	0.045	0.062	0.065	0.051	0.058	0.063	0.048	0.060	0.064	0.057	0.057	0.057	
3	0.056	0.063	0.068	0.069	0.070	0.082	0.063	0.067	0.076	0.063	0.074	0.069	
4	0.082	0.052	0.063	0.062	0.062	0.071	0.072	0.057	0.067	0.066	0.065	0.065	
5	0.082	0.048	0.072	0.050	0.072	0.065	0.065	0.061	0.068	0.067	0.062	0.064	
6	0.087	0.098	0.264	0.111	0.128	0.209	0.100	0.114	0.234	0.150	0.149	0.149	
7	0.050	0.048	0.095	0.053	0.080	0.096	0.052	0.065	0.095	0.064	0.077	0.071	
8	0.067	0.056	0.115	0.044	0.092	0.119	0.055	0.076	0.117	0.079	0.085	0.083	
9	0.067	0.063	0.071	0.054	0.071	0.081	0.060	0.067	0.077	0.067	0.069	0.068	
Average	0.067	0.060	0.099	0.062	0.077	0.097	0.064	0.069	0.098	0.075	0.079		

Table 5. Means for 3-hydroxytyramine by population within 3 nitrogen levels and within 2 copper levels.

Population	Nitrogen Level			Copper Level	
	1	2	3	1	2
1	52.57	54.93	50.29	58.38	48.57
2	29.57	13.00	14.00	23.85	13.86
3	54.79	40.57	38.29	49.66	39.42
4	53.57	45.50	40.79	51.38	41.85
5	48.86	36.14	35.64	44.57	35.85
6	8.14	4.00	3.71	6.43	4.14
7	78.43	58.64	65.50	73.09	61.95
8	82.14	82.43	99.57	94.13	81.94
9	35.92	30.93	34.21	36.47	30.90
Average	49.33	40.68	42.44	48.66	39.83

Table 6. Means for 3-hydroxytyramine by populations within copper treatments at three nitrogen levels.

Popu- lations	Copper I			Copper II		
	N ₁	N ₂	N ₃	N ₁	N ₂	N ₃
1.	66.86	57.28	51.00	38.29	52.57	54.86
2.	47.57	12.86	11.14	11.57	13.14	16.86
3.	61.57	45.86	41.57	48.00	35.28	35.00
4.	66.43	43.86	43.86	40.71	47.14	37.71
5.	64.29	30.29	39.14	33.43	42.00	32.14
6.	11.86	4.00	3.42	4.43	4.00	4.00
7.	98.86	54.29	66.14	28.00	63.00	64.86
8.	87.57	88.00	106.86	76.71	76.86	92.29
9.	43.28	31.86	34.28	28.57	30.00	34.14
Average	60.92	40.92	44.16	37.74	40.44	41.31

Table 7. Ratio of leaf copper to thin juice copper in relation to treatments.

Popu- lation	<u>0 lbs. Cu</u>			<u>100 lbs. Cu</u>			<u>Cu₁ + Cu₂ Nitrogen</u>			<u>Copper</u>		Total Leaf Cu. to Thin Juice Cu
	N ₁	N ₂	N ₃	N ₁	N ₂	N ₃	N ₁	N ₂	N ₃	0 lbs.	100 lbs.	
1	30.53	41.81	23.47	26.68	34.53	23.74	28.48	37.47	23.54	30.37	27.51	28.8
2	40.31	33.92	27.69	34.73	35.38	29.11	37.31	34.60	28.44	33.44	33.11	33.3
3	47.32	34.29	30.29	29.14	32.17	26.33	36.65	32.97	27.80	36.35	28.93	32.0
4	31.45	50.33	34.35	40.10	38.85	29.75	35.13	43.96	31.90	37.17	35.94	36.8
5	34.06	43.89	33.43	42.80	35.47	34.52	37.62	38.44	34.12	36.36	37.31	37.0
6	24.41	22.62	7.82	18.92	15.62	8.88	21.11	18.43	8.35	14.23	13.32	13.8
7	46.48	39.65	19.58	31.43	27.93	20.01	37.94	31.98	19.93	31.70	25.19	27.9
8	25.69	29.34	15.90	37.64	18.64	15.34	30.67	22.12	15.62	21.91	20.38	20.9
9	31.13	28.46	21.93	27.50	25.42	20.07	29.42	26.85	20.70	27.04	23.75	25.3

oxidizes 3-hydroxytyramine as a result of host-parasite relationships or oxidizes 3-hydroxytyramine all the time, it is not possible at this time to state the relationship of 3-hydroxytyramine to resistance of beets to leaf spot. If the 3-hydroxytyramine is oxidized as a result of the pathogen invading the leaf, then there should not be a negative relationship between the enzyme polyphenoloxidase and 3-hydroxytyramine when data are taken from non-infected plants. Speculatively if polyphenoloxidase is involved in both synthesis and oxidation of 3-hydroxytyramine, other phenols may inhibit oxidation but not synthesis of 3-hydroxytyramine. This would explain susceptible genotypes having high 3-hydroxytyramine content. These genotypes would have genes for production of phenol inhibitors to the polyphenoloxidase enzyme which would mask the expression of genes for resistance to leaf spot through retention of 3-hydroxytyramine in the reduced state. This hypothesis may be further substantiated by the fact that the two most susceptible populations, five and six, have higher leaf copper content than the resistant varieties (Table 3) and that population five and six also have equal or larger amounts of copper in the thin juice when compared to all other resistant populations. One investigator (4) has shown that Quercetin, a flavonol found in sugar beet leaves, acts as an anti-oxident of 3-hydroxytyramine.

Table 6 shows that the effect of nitrogen on 3-hydroxytyramine is not consistent and the effect of nitrogen upon the amount of leaf copper is not of a magnitude which causes a consistent interaction in all genotypes with respect to positively correlating the amount of copper with 3-hydroxytyramine content.

Means by population over all nitrogen treatments, ignoring the copper treatments, are given in Table 8. All the impurity components (weight, conductivity, Cu, K, Na, N_2 , Ca, Mg.) showed an increase with higher nitrogen treatment (Table 9). Leaf copper, cobalt, iron, 3-hydroxytyramine, sucrose, purity, and recoverable sugar showed a decrease in amount with increasing nitrogen application (Table 9). There are no apparent good correlations between any of these characters over all populations.

The F_1 (population 7), was intermediate to the two parents (population 8 & 9) with respect to 3-hydroxytyramine, cobalt, magnesium, sucrose, conductivity and thin juice copper, potassium and sodium (Table 8). Positive heterosis was demonstrated for leaf copper, weight, purity and recoverable sugar. Negative heterosis was demonstrated for calcium and iron (Table 8). The ratio of leaf copper to thin juice copper was always higher in the F_1 hybrid over the two parents. Since 3-hydroxytyramine content in the F_1 was intermediate to the parents the relationship between copper content and 3-hydroxy-

Table 8. Means by population over all nitrogen treatments, ignoring copper split.

Population	3-Hydroxy-tyramine	Leaf Copper	Cobalt	Calcium	Magnesium	Iron	Weight	% Sucrose
1	51.9772	1.9051	1.0758	1015.05	662.16	17.50	6.54	13.86
2	18.2443	1.8957	1.1420	1060.24	953.97	17.74	6.26	14.31
3	42.7551	2.2104	1.0091	1190.66	831.30	14.76	11.44	14.62
4	45.3551	2.3906	1.0616	1356.03	970.76	16.97	14.59	16.02
5	38.5996	2.3700	1.0602	1256.18	889.22	19.12	11.23	14.74
6	5.2222	2.0551	1.2393	1204.73	1045.65	31.52	5.84	14.53
7	65.0216	1.9817	1.1473	1282.66	1002.17	16.26	12.90	15.27
8	85.1103	1.7382	1.2791	1432.67	1195.87	17.08	6.04	15.98
9	32.3552	1.7195	1.0876	1298.58	991.81	26.45	8.24	13.90
Mean	42.73827	2.0296	1.1224	1232.99	949.22	19.71	9.23	14.80

Population	Conductivity	% Purity	Rec. Sugar	Thin Juice Copper	Potassium	Sodium	N ₂
1	1.2556	93.80	0.7961	0.6607	72.84	32.59	26.63
2	1.2222	93.83	0.7971	0.5724	54.66	46.70	32.94
3	1.0444	95.06	1.5095	0.6856	59.71	33.43	24.45
4	1.2067	94.39	2.0599	0.6538	76.90	26.22	39.61
5	1.3511	94.18	1.4619	0.6442	71.24	39.79	35.60
6	1.1445	91.35	0.7010	1.4949	83.80	23.42	85.45
7	1.3711	93.74	1.7056	0.7087	92.05	25.85	38.73
8	1.1244	93.57	0.8353	0.8251	80.29	15.66	55.48
9	1.6511	91.46	0.9492	0.6809	114.24	30.78	42.60
Mean	1.2635	93.49	1.2018	0.7696	78.41	30.49	42.39

Table 9. Means by nitrogen level for all characters ignoring the copper treatment split.

Character	Nitrogen		
	0	100	250
Weight Kg.	8.95	9.39	9.34
Percent sucrose	15.80	15.18	13.43
Conductivity	0.9533	1.1437	1.5822
Percent Purity	95.84	93.85	90.76
Recov. Sugar	1.3066	1.2590	1.0396
Leaf Copper	2.0504	2.0870	1.9514
Thin Juice Copper	0.6427	0.6887	0.9773
Potassium	65.12	71.65	98.47
Sodium	16.59	27.58	47.30
N ₂	22.96	35.41	68.80
Cobalt	1.1812	1.1105	1.0756
Calcium	1220.1965	1157.6704	1321.0657
Magnesium	836.0410	899.1987	1112.3925
Iron	25.6668	17.6395	13.7456
3-hydroxytyramine	47.1773	39.3922	41.6440

tyramine content is not apparent.

Summary

The relationship of several characters to 3-hydroxytyramine production and their possible interaction with expression of disease resistance in nine genotypes was studied. There were no conclusive relationships between any of the characters and 3-hydroxytyramine production which held for all populations. Interaction components for populations, copper, and nitrogen level were not consistent between genotypes. There was a general indication that nitrogen inhibited copper translocation from the root to the leaves. No inhibitory mechanism is apparent and no relationship to 3-hydroxytyramine is demonstrated by the plant data.

This study points out that primary metabolites are not related to 3-hydroxytyramine and disease resistance. The relationship is probably altered by secondary metabolites per se such as other phenolic compounds in the plant.

The inheritance of these phenolic compounds, such as Quercitin and Vitexin, and their effect on 3-hydroxytyramine being in the oxidized or reduced state is essential in linking 3-hydroxytyramine as a significant entity involved in resistance of a beet plant to leaf spot.

The reaction of the plant to the organism (Cercospora beticola) or the host-parasite interaction in relation to these compounds then is of primary concern at this time.

Literature Cited

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RAPID DIGESTION PROCEDURES FOR USE IN DETERMINATION OF TOTAL NITROGEN AND METALLIC IONS IN SUGARBEET SAMPLES

Grace W. Maag ^{1/}

Introduction

Digestion of sugarbeet material is always a problem because of the high sugar content involved. The sugar causes excessive foaming and charring and, consequently, the digestion is usually a long, tedious process. When there are many samples to be analyzed, digestion time can become an important factor.

In this report, I am limiting the discussion to digestion of sugarbeet samples for atomic absorption spectrophotometric analysis and for total nitrogen determinations, although the digested samples resulting from the procedures, can be used sometimes for other analyses.

Since atomic absorption spectrophotometry has become an accurate and highly sensitive method for determination of many metallic ions, it is essential to get the samples into solution as easily as possible and with the least number of interfering ions before proceeding with the analysis. Total nitrogen determinations are always important in purity studies.

Digestion for Atomic Absorption Analyses

Most atomic absorption spectrophotometric analysis procedures suggest digestion of samples with nitric acid, or a mixture of nitric and perchloric acid. Sometimes a mixture of nitric, perchloric, and sulfuric acids are used. We have found that nitric acid used alone is unsatisfactory for sugarbeet samples because of excessive foaming and incomplete digestion. The nitric-perchloric acid mixture will eventually give complete digestion but several additions of the acid mixture to the digesting sample must be made before complete digestion takes place. Both acids decompose quite rapidly upon heating and boil off easily. This procedure is also dangerous because if the mixture is allowed to boil down too far, in the presence of organic matter, a violent explosion can result due to the formation of the unstable oxides of chlorine.

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The mixture of nitric, perchloric, and sulfuric acids is a much safer combination to use because the sulfuric acid is more stable at the higher temperatures and, therefore, its presence helps prevent the mixture from going to dryness and thus tends to prevent the formation of the explosive oxides of chlorine. Again, this mixture may require quite a long time for complete digestion and also requires additions of more acid during the process.

Bolin and Stamberg (1) suggested the use of a digestion mixture of perchloric and sulfuric acids with some molybdenum added as a catalyst for determination of phosphorus. The presence of the molybdenum markedly increases the rate of oxidation of organic matter. This mixture is most satisfactory for digestion of many samples but in atomic absorption analyses the high sulfate ion content resulting sometimes causes interference. Bolin and Stamberg suggested the following proportions:

30 g $\text{Na}_2\text{MoO}_4 \cdot 2\text{H}_2\text{O}$ in 150 ml H_2O

Add slowly 150 ml concentrated sulfuric acid. Cool.

Add 200 ml of 70 - 72% perchloric acid.

We have modified this procedure somewhat for atomic absorption sample preparation to cut down on the sulfate ion content. As a result we use the following combination:

Mix together

350 ml 70 - 72% HClO_4

100 ml Conc. H_2SO_4

1500 ml Conc. HNO_3

Add to:

2 g $\text{Na}_2\text{MoO}_4 \cdot 2\text{H}_2\text{O}$ in 100 ml H_2O

The sodium molybdate content has been cut down from the proportions suggested by Bolin and Stamberg to decrease the sodium ion content which causes discoloration of the flame in the atomic absorption analyses.

Sugarbeet thin juice samples may be read spectrophotometrically without digestion but pressed juice and dried leaf and petiole samples must be digested. The proportion of the digestion mixture to the amount of sample may be adjusted as required. The procedure we use is as follows:

5 ml of the acid digestion mixture is added to 0.5 g of finely ground dried leaf or petiole sample in a pyrex digestion tube. If this mixture is allowed to stand over night, foaming is reduced considerably when first heated. Heat at medium temperature on a digestion rack. We use an electric rotary digestion rack. The sample will boil for a while, then a vigorous reaction will take place after which the sample becomes colorless. After this reaction, continue heating at a high temperature until the sulfuric acid crawls up the tube to clean the sides of the tube of any remaining sample particles. A total of about 25 minutes is required for the complete digestion. Cool. Add water to make up to 25 ml. If necessary, further dilution of the sample may be made if the concentration of the metallic ions is too high to read on the atomic absorption spectrophotometer within the range desired. In some determinations, additions of other reagents may be necessary as indicated in methods outlined in the procedure for a particular element. For example, in calcium determinations, lanthanum chloride is added to mask interference by phosphorus and aluminum ions and the sulfate ion concentration in the diluted sample and in the standard solution should be about 1%. All samples are read in comparison with standard solutions on an atomic absorption spectrophotometer.

Digestion for Total Nitrogen

Total nitrogen determinations are time consuming and difficult, especially when it is desirable to pick up the nitrate nitrogen along with other nitrogen present.

Many variations of the Kjeldahl procedure have been used. The procedure which we have found to be the most satisfactory and which will also pick up nitrate nitrogen is described in the Association of Official Agricultural Chemists "Methods of Analysis" (2). This procedure uses salicylic acid in concentrated sulfuric acid along with sodium thiosulfate. Copper and potassium sulfate (Kel Pak) are added as catalysts and to raise the boiling point. The total digestion time required for this procedure on dried plant or juice samples is about 4 - 5 hours. The nitrate present reacts with the salicylic acid in the presence of strong acids and thus is eventually converted to ammonium sulfate in the digestion process.

The new digestion mixture given here still maintains the use of salicylic acid along with concentrated sulfuric acid. In addition some perchloric acid is added as a strong oxidant and some sodium molybdate as a catalyst. The reagents are made up as follows. Reagent I should be made fresh just before use.

Reagent I

150 ml conc. H_2SO_4

25 g salicylic acid

Mix well

Add 200 ml 70 - 72% HClO_4

Reagent II

10 g $\text{Na}_2\text{MoO}_4 \cdot 2\text{H}_2\text{O}$ in 150 ml H_2O

In digesting thin juice samples, place 0.5 ml thin juice in a 50 ml pyrex digestion tube or micro-Kjeldahl flask. 2-3 boiling stones are added to prevent bumping. Add 1.3 - 1.5 ml of Reagent I and allow to stand at least 30 minutes or over night to allow the nitrate to react with the salicylic acid. Just before digestion, add 1.0 ml of Reagent II (sodium molybdate solution). Place on a digestion rack and heat at medium temperature. The mixture will boil for a while, then a more vigorous reaction will take place, after which the mixture becomes colorless. Turn to high heat until the sulfuric acid crawls well up on the sides of the tube. This will clean the tube of any remaining sample particles and also drive off excess hydrogen chloride which may interfere with the color formation if direct nesslerization is used later. After digestion, the samples may be read by direct nesslerization or by a steam distillation method. If a steam distillation method is used, larger amounts of sample and digestion mixture can be used.

The direct nesslerization procedure involves first adding 10 - 15 ml of distilled water to the cool digested sample in the 50 ml calibrated digestion tube. Some of the excess acid is neutralized by the addition of 2 - 3 ml of 10 percent sodium hydroxide. Allow this mixture to cool. Add 1 - 2 ml of 2 percent gum ghatti solution to aid in stabilization of the colloidal solution when it is formed later. Blow in 12 - 14 ml Nessler's solution. Make up to 50 ml with distilled water. Mix well and read at 490 m μ on a spectrophotometer. The amount of sodium hydroxide and Nessler's solution should be adjusted to the samples being analyzed. Some types of samples may require more acid in digestion than others. The Nessler's solution must be sufficient for the colored colloidal compound of dimercuric ammonium iodide to form. The pH of the resulting solution should be about 12. If the pH is too low, a red precipitate will form. If the pH is too high, the resulting solution may become cloudy. Cloudiness may also result if the Nessler's solution is not mixed thoroughly as it is added to the sample. Also, contaminants, such as silicates or a high concentration of soluble salts, may cause precipitation of the colloidal compound. For this reason it is difficult to read digested leaf or petiole samples by direct nesslerization. The resulting colloidal solution, if properly prepared, should be reddish-brown in color and sparkling clear.

Since some total nitrogen samples can not be read by direct nesslerization after digestion, a steam distillation method can be used. It is preferable to digest these samples in micro-Kjeldahl flasks which can be used later on a steam distillation set-up. After digestion, the sides of the cooled sample flasks are washed down with about 10 ml of distilled water. Excess 40 percent sodium hydroxide is added to make the sample basic and the ammonia is driven off by steam distillation. The ammonia may be collected in Nessler's solution and read as above. We prefer collecting the ammonia in a 2 percent boric acid solution which contains bromcresol green indicator and titrating the resulting solution with 0.0143N sulfuric acid (3). Each ml of the 0.0143N sulfuric acid used is equivalent to 0.2 mg nitrogen in the sample.

Table I shows the average amount of total nitrogen in mg per 100 ml thin juice obtained on three different thin juice samples. Each thin juice sample was analyzed three different ways as follows: 1. 0.5 ml portions of each sample were digested with 1.4 ml of digestion mixture A (H_2SO_4 , $HClO_4$, salicylic acid and Na_2MoO_4) and read by direct nesslerization. The amount of sample and reagents added is kept to a minimum here because direct nesslerization is used for reading after digestion. 2. Duplicate 1.0 ml portions were digested with 5.0 ml of digestion mixture A and read by the steam distillation-boric acid-sulfuric acid method. 3. Duplicate 1.0 ml portions were digested with 5.0 ml of digestion mixture B (H_2SO_4 , salicylic acid, $Na_2S_2O_3$, and Kel Pak) and read by the steam distillation-boric acid-sulfuric acid method.

Table I. Total nitrogen determination on three different thin juice samples by three different methods.

Sample	Method I	Method II	Method III
	Digestion Mixture A (H_2SO_4 , $HClO_4$, salicylic acid, Na_2MoO_4)		Digestion Method B (H_2SO_4 , salicylic acid, $Na_2S_2O_3$, Kel Pak)
	Direct Nesslerization	Steam Distillation	Steam Distillation
1.	18.38 mg N/100 ml	19.00 mg N/100 ml	18.88 mg N/100 ml
2.	14.15	14.00	13.95
3.	61.75	61.90	61.80

Thin juice samples were also run with known amounts of nitrate nitrogen added to the samples and check results were satisfactory.

When analyzing pressed juice samples, best results are obtained when at least 5.0 ml of the digestion mixture A are used for each ml of pressed juice. Again three different pressed juice samples were analyzed using digestion mixture A. The results were checked against results obtained on the same three samples digested with digestion mixture B. The steam distillation-boric acid-sulfuric acid method was used in each case to read the sample after digestion. Table II shows results of these samples with the total nitrogen given in mg nitrogen per 100 ml pressed juice.

Table II. Results of analysis of three different pressed juice samples digested by two methods.

	Digestion Mixture A	Digestion Mixture B
Sample	(H_2SO_4 , HClO_4 , salicylic acid, Na_2MoO_4)	(H_2SO_4 , salicylic acid, $\text{Na}_2\text{S}_2\text{O}_3$, Kel Pak)
1.	82.25 mg N/100 ml	82.25 mg N/100 ml
2.	153.00	153.25
3.	61.00	60.60

Finely ground dried leaf or petiole samples may also be digested with the sulfuric, perchloric, salicylic acid mixture with sodium molybdate added as a catalyst. Again it is best to allow the samples to stand over night after addition of the acid digestion mixture to allow the nitrate to react with the salicylic acid and to reduce foaming. Best results were obtained when 6 - 10 ml of the digestion mixture were used with 0.2 gram dried sample. 1.0 ml of the sodium molybdate solution is added just before digestion. The digestion procedure is carried out the same as with thin and pressed juice samples. The direct nesslerization method is not a satisfactory means for reading the sample after digestion because the silicates present, along with other contaminants, cause precipitation of the colloidal solution when the Nessler's reagent is added. Consequently, the steam distillation method was used for reading.

Table III gives the mg nitrogen per 100 g. sample for a single dried leaf sample. Four 0.2 g samples were digested using 10 ml of the new digestion mixture A, and four 0.2 g samples were digested using 6 ml of the digestion mixture B. All were read using the steam distillation method in which the ammonia was collected in weak boric acid solution and titrated with 0.0143 N sulfuric acid.

Table III. Mg nitrogen per 100 g. dried leaf sample obtained in four duplicate analyses by two different digestion methods on the same sample.

Sample	Digestion Mixture A	Digestion Mixture B
1.	4650 mg N/100 g	4670 mg N/100 g
1.	4680	4680
1.	4620	4700
1.	4670	4660

Summary

Good results have been obtained with new faster digestion procedures on sugarbeet materials. The digestion mixture for sample digestion for atomic absorption spectrophotometry is made of concentrated nitric, perchloric, and sulfuric acids with a small amount of sodium molybdate added as a catalyst. For total nitrogen determinations a mixture of concentrated sulfuric and perchloric acids are used with salicylic acid added to aid in picking up the nitrate nitrogen, sodium molybdate again is added as a catalyst. The amount of digestion solution is adjusted to the kind and amount of sample used.

Literature Cited

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P A R T V

Progress reports of research conducted at
Michigan State University, East Lansing, Michigan
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and
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Staff of Sugarbeet Investigations, ARS-USDA
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EVALUATION OF SUGARBEET VARIETIES AND BASIC BREEDING MATERIAL SUITABLE FOR THE GREAT LAKES REGION

The cooperative evaluation program of the past several years was again continued in 1967. Stands in all tests were good. One test was abandoned due to nematodes. This report is divided into two sections: 1) Agronomic evaluation which contained five hybrids and SP6322-0 in 6 x 6 latin square designs; 2) Area Evaluation tests composed of hybrids being retested from the 1966 test and hybrids being tested for the first time in 36 variety randomized block designs with 8 replications at Sebewaing, Michigan and 3 replications at Ottawa, Ohio.

Section One: Agronomic Evaluation

The results of the tests at Bay City, Michigan; Chatham, Ontario; New Cleveland, Ohio and Prentis, Ohio are included in a summary of performance table. This table gives performance in percent of the general mean. The combined data were then analyzed across locations, significant differences were found in all categories. Of the female single crosses used in these hybrids the SL(129 x 133)ms was the best in quality (sugar per ton) and near enough to the best in yield of roots to give the best yield of extractable sugar per acre. In both 1964 and 1965 SP6322-0 was slightly better as a pollinator of SL(129 x 133)ms than SP5822-0. The combined data for recoverable sugar per acre for 1967 shows a significant difference between these pollinators. The hybrid SL(129 x 133)ms X SP6322-0 proved to be the best in almost all comparisons. However, this hybrid lacks leaf spot resistance as shown in the test at New Cleveland, Ohio.

AGRONOMIC EVALUATION

TABLE OF PERFORMANCES IN PERCENT OF THE GENERAL MEAN OF THE TEST

Entry	1 [#]	2	3	4	5	6	LSD 5%	General Mean
Tests								
<u>100# bags Recoverable Sugar per Acre</u>								
Bay City, Mich.	101.9	103.3	98.6	95.7	100.3	100.3	NS	109.0
Chatham, Ontario	102.6	106.7	103.2	94.9	103.7	88.9	8.9	66.6
New Cleveland, Ohio	98.7	107.2	102.1	95.5	99.7	96.8	5.2	82.5
Prentis, Ohio	103.3	106.5	98.8	95.1	100.3	96.1	NS	39.6
Average	101.6	105.9	100.7	95.3	101.0	95.5	4.2 [@]	
<u>Roots in Tons per Acre</u>								
Bay City	100.0	101.2	100.7	97.2	100.5	100.5	NS	37.4
Chatham	101.4	103.5	103.0	100.3	101.1	90.8	NS	24.6
New Cleveland	98.7	103.4	102.8	97.2	101.6	96.2	NS	23.7
Prentis	100.5	105.6	101.6	96.8	100.6	94.9	NS	14.3
Average	100.2	103.4	102.0	97.9	101.0	95.6	3.4 [@]	
<u>Recoverable Sugar per Ton a.</u>								
Bay City	101.8	102.1	97.9	98.5	99.7	99.8	NS	291
Chatham	101.5	103.2	100.2	94.7	102.4	97.9	4.4	271
New Cleveland	100.0	103.6	99.4	98.2	98.1	100.7	NS	288
Prentis	102.3	100.2	98.6	99.0	99.0	101.0	NS	272
Average	101.4	102.3	99.0	97.6	99.3	99.9	2.5 [@]	
# Entry No.	Seed Number							
1	SL(129 x 133)ms x SP5822-0							
2	SL(129 x 133)ms x SP6322-0							
3	[(SP6121 x 3561)3561]ms x SP5822-0							
4	(SP6121 x 4661)ms x SP5822-0							
5	648H2 x SP5822-0							
6	SP6322-0							

[@]Calculated from an analysis of % performance of entries vs. tests.

a. Standard Footnote on page 293.

AGRONOMIC EVALUATION

TABLE OF PERFORMANCES IN PERCENT OF THE GENERAL MEAN OF THE TEST

Entry	1 [#]	2	3	4	5	6	LSD 5%	General Mean
Tests								
<u>Percent Sucrose^{a.}</u>								
Bay City, Mich.	102.0	101.7	97.8	99.0	99.7	99.8	NS	16.00
Chatham, Ontario	101.1	101.7	100.1	96.8	101.3	98.9	2.9	15.73
New Cleveland, Ohio	100.8	103.6	98.6	99.0	97.2	100.7	NS	16.17
Prentis, Ohio	101.7	100.1	99.0	99.1	99.9	100.1	NS	15.24
Average	101.4	101.8	98.9	98.5	99.5	99.9	1.9 [@]	

Percent Purity

Bay City	99.3	100.3	100.1	99.8	100.0	100.0	NS	95.81
Chatham	100.0	100.7	100.1	99.2	100.5	99.5	1.1	93.08
New Cleveland	99.6	99.9	100.4	99.6	100.5	100.0	.5	94.72
Prentis	100.5	100.3	100.0	99.6	99.8	99.7	NS	94.62
Average	100.0	100.3	100.2	99.6	100.2	99.8	.5 [@]	

[#] Entry No.	Seed Number
1	SL(129 x 133)ms x SP5822-0
2	SL(129 x 133)ms x SP6322-0
3	[(SP6121 x 3561) 3561]ms x SP5822-0
4	(SP6121 x 4661)ms x SP5822-0
5	648H2 x SP5822-0
6	SP6322-0

[@] Calculated from an analysis of % performance of entries vs. tests.

Standard Footnotes:

- Data obtained according to procedures as given in "A Rapid and Practical Method of Determining Extractable White Sugar as May be Applied to the Evaluation of Agronomic Practices and Grower Deliveries in the Sugar Beet Industry" by S. T. Dexter, M. G. Frakes, and F. W. Snyder, The Journal of American Society of Sugar Beet Technologists, Volume 14, No. 5, pp 433-454.
- Rating scale: 0 = no evidence of disease; 10 = complete nectosis due to leaf spot.

AGRONOMIC EVALUATION TEST

Conducted by: John Niederer

Location: Walter Helmreich Farm - Bay City, Michigan

Cooperation: Farmers & Manufacturers Beet Sugar Association

Date of Planting:

Date of Harvest:

Experimental Design: 6 x 6 Latin Square

Size of Plots: 4 rows 30' long x 28" between rows

Harvested Area per Plot for Root Yield: 4 rows - 25' long

Samples for Sucrose Determination: One 10-beet sample was selected at
random after plot was harvested

Stand Counts:

Recent Field History: 1965 - Alfalfa 500# 20% P.

1966 - Beans 300# 10-20-10 per acre Mg. + Zn.

1967 - Sugarbeets 600# 8-32-16 per acre

Mg. + Boron in the row

50# N as Anhydrous

Fertilization of Beet Crop:

Black Root Exposure:

Leaf Spot Exposure:

Other Diseases & Pests:

Soil & Seasonal Conditions:

Reliability of Test:

Cooperator: F & M Beet Sugar Assn. & Monitor Sugar Co. Year 1967
 Location: Walter Helmrieck Farm, Bay City, Michigan Expt. 7
 6 x 6 Latin Square

Variety	Recov. Sugar per A. ^a Cwt.	Roots per Acre Tons	Sugar per Ton Lbs.	Sucrose ^a %	Purity ^a %	Beets per 100' ¹ No.
SL(129 x 133)ms x SP5822-0	111.1	37.4	297	16.32	95.63	98
SL(129 x 133)ms x SP6322-0	112.6	37.9	297	16.27	96.06	106
[(SP121 x 3561)3561]ms x SP5822-0	107.4	37.7	285	15.65	95.88	106
(SP6121 x 4661)ms x SP5822-0	104.3	36.4	287	15.85	95.64	83
648H2 x SP5822-0	109.3	37.6	290	15.95	95.82	105
SP6322-0	109.3	37.6	291	15.97	95.81	104
General Mean	109.0	37.4	291	16.00	95.81	101
S.E. Var. Mean	2.28	.539	3.49	.2023	.2376	.45
Above as % Gen. Mean	2.09	1.43	1.20	1.26	.25	.45
LSD 5% Point	NS	NS	NS	NS	NS	NS

Latin Square Analysis

Variance Table

Mean Squares

Source of Variation	D/F	Recov. Sugar	Roots	Sugar per T.	Sucrose	Purity	Beets per 100' ¹
Between Rows	5	61.72	2.24	118	.0832	1.1781	65
Between Columns	5	32.27	1.89	82	.1444	.7735	96
Between Varieties	5	50.00	1.70	149	.3852	.1534	286
Remainder (Error)	20	31.13	1.71	73	.2455	.3387	123
Total	35						
Calculated F. Value		1.61	.99	2.04	1.57	.45	2.33

Standard Footnote a on page 293.

AGRONOMIC EVALUATION TEST

Conducted by: C.E. Broadwell & R.G. Fraser

Location: Canada & Dominion Sugar Company Experimental Farm
Dover Township

Cooperation: Canada & Dominion Sugar Company, Ltd.

Date of Planting: April 20, 1967

Date of Harvest: Rep's # 1 & 2--September 29

Rep # 3--September 30

Rep's # 4, 5 & 6--October 2

Experimental Design: 6 x 6 Latin Square--Design # 1

Size of Plots: 4 rows x 30' long x 24" between rows

Harvested Area per Plot for Root Yield: 4 rows--30' long

Samples for Sucrose Determination: One 10-beet sample was selected at
random after plot was harvested.

Stand Counts: Harvested beets counted when weight

Recent Field History: 1965--corn 400[#] 5-20-20 + 82[#] of actual N as
Anhydrous Ammonia

1966--peas 300[#] 5-20-20 + 100[#] of Ammonium

Fertilization of Beet Crop: 600[#] 5-20-20 broadcast & harrowed in.
275[#] 5-20-20 banded 2 1/2" below seed.

Black Root Exposure: none

Leaf Spot Exposure: None

Other Diseases & Pests: None

Soil & Seasonal Conditions: Seed Bed--ideal conditions

Adquate Moisture Throughout Growing Season

Reliability of Test: Good

Cooperator: Canada & Dominion Sugar Co. & F&M Beet Sugar Assn. Year 1967
 Location: Dover Farm, Catham, Ontario Expt. 1
 6 x 6 Latin Square

Variety	Recov. Sugar per A. ^a Cwt.	Roots per Acre Tons	Sugar per Ton ^a Lbs.	Sucrose ^a %	C.J. Purity ^a %	Beets per 100' ^a No.
SL(129 x 133)ms x SP5822-0	68.3	24.9	275	15.92	93.10	125
SL(129 x 133)ms x SP6322-0	71.0	25.4	280	16.01	93.76	133
[(SP6121 x 3561)3561]ms x SP5822-0	68.7	25.3	271	15.76	93.19	129
(SP6121 x 4661)ms x SP5822-0	63.2	24.6	257	15.23	92.29	65
643H2 x SP5822-0	69.0	24.8	277	15.94	93.53	123
SP6322-0	59.2	22.3	265	15.57	92.62	108
General Mean	66.6	24.6	271	15.73	93.03	114
S.E. Var. Mean	1.98	.697	4.18	.155	.333	2.97
Above as % Gen. Mean	2.97	2.8	1.54	.99	.36	2.61
LSD 5% Point	5.9	NS	12	.46	.98	9

Latin Square Analysis

Variance Table

Mean Squares

Sorce of Variation	D/F	Recov. Sugar	Roots	Sugar per T.	Sucrose	Purity	Beets per 100'
Between Rows	5	84.82	3.47	381	.9097	.7654	67
Between Columns	5	21.58	3.43	367	.6561	.7321	292
Between Varieties	5	119.95	7.86	448	.5191	1.8077	3878
Remainder (Error)	20	23.61	2.91	105	.1447	.6657	53
Total	35						
Calculated F. Value		5.08**	2.70	4.27**	3.59*	2.72*	73.17**

Standard Footnote a, on page 293:

AGRONOMIC EVALUATION TEST

Conducted by: John Niederer

Location: Tom Knieven Farm - New Cleveland, Ohio

Cooperation: Farmers & Manufacturers Beet Sugar Association

Date of Planting:

Date of Harvesting:

Experimental Design: 6 x 6 Latin Square

Size of Plots: 4 rows 30' long x 32" between rows

Harvested Area per Plot for Root Yield: 4 rows - 25' long

Samples for Sucrose Determination: One 10-beet sample was selected at
random after plot was harvested

Stand Counts:

<u>Recent Field History:</u>	1965 - Clover	3-4 tons Manure plowed down
	1966 - Corn	350# 6-24-12 in row
		100# NH_3 Sidedressed
	1967 - Sugarbeets	500# 5-20-20 in row
		150# 6-24-12 Plowed down
		80# NH_3 Sidedressed

Fertilization of Beet Crop:

Black Root Exposure:

Leaf Spot Exposure:

Other Diseases & Pests:

Soil & Seasonal Conditions:

Reliability of Test:

Cooperator: F & M Beet Sugar Assn. & Buckeye Sugar Inc. Year 1967
 Location: Knieven Farm, New Cleveland, Ohio Expt. 3
 6 x 6 Latin Square

Variety	Recov. Sugar per A. Cwt.	Roots per Acre Tons	Sugar per Ton ^a Lbs.	Sucrose ^a %	Purity ^a %	Beets per 100' No.	Leaf Spot ^b Rating
S1(129 x 133)ms x SP5822-0	81.5	28.4	288	16.30	94.30	122	4.3
SL(129 x 133)ms s SP6322-0	88.5	29.7	298	16.76	94.68	124	3.3
[(SP121x3561)3561]ms x SP5822-0	84.2	29.6	286	15.94	95.13	122	2.7
(SP6121 x 4661)ms x SP5822-0	78.8	27.9	283	16.02	94.34	117	2.5
648H2 x SP5822-0	82.3	29.2	282	15.73	95.16	126	3.0
SP6322-0	79.8	27.7	290	16.28	94.73	125	2.0
General Mean	82.5	28.7	288	16.17	94.72	122.5	3.1
S.E. Var. Mean	1.46	.187	3.9	.27	.1659	2	.13
Above as % Gen. Mean	1.77	.65	1.4	1.68	.175	1.7	4.2
LSD 5% Point	4.3	NS	NS	NS	0.49	NS	.4

Latin Square Analysis

Variance Table

Mean Squares

Source of Variation	D/F	Recov. Sugar	Roots	Sugar per T.	Sucrose	Purity	Beets per 100'	Leaf Spot
Between Rows	5	92.36	26.01	455	1.1479	.2979	26	.40
Between Columns	5	20.71	4.19	110	0.3053	.6353	19	.20
Between Varieties	5	72.70	4.57	205	0.7791	.8166	59	4.60
Remainder (Error)	20	12.82	2.10	93	0.4447	.1651	25	.10
Total	35							
Calculated F. Value		5.67**	2.18	2.19	1.75	4.95**	2.39	4.60**

Standard Footnotes a, and b, on page 293.

AGRONOMIC EVALUATION TEST

Conducted by: John Niederer

Location: Russell Bros. Farm - Prentis, Ohio

Cooperation: Farmers & Manufacturers Beet Sugar Association

Date of Planting:

Date of Harvesting:

Experimental Design: 6 x 6 Latin Square

Size of Plots: 4 rows 30' long x 32" between rows

Harvested Area per Plot for Root Yield: 4 rows - 25' long

Samples for Sucrose Determination: One 10-beet sample was selected at
random after plot was harvested

Stand Counts:

Recent Field History: 1965 - None available

1966 - Corn 250# 6-24-12 in row

1967 - Sugarbeets 500# 6-24-12 per acre Mn.

80# NH_3 Sidedressed

Fertilization of Beet Crop:

Black Root Exposure:

Leaf Spot Exposure:

Other Diseases & Pests:

Soil & Seasonal Conditions:

Reliability of Test:

Cooperator: F & M Beet Sugar Assn & Buckeye Sugar Inc.

Year 1967

Location: Russell Brothers Farm, Prentis, Ohio

Expt. 2

6 x 6 Latin Square

Variety	Recov. Sugar per A. ^a Cwt.	Roots per Acre Tons	Sugar per Ton ^a Lbs.	Sucrose ^a %	Purity ^a %	Beets per 100' No.
SL(129 x 133)ms x SP5822-0	40.9	14.4	278	15.49	95.13	106
SL(129 x 133)ms x SP6322-0	42.1	15.1	272	15.26	94.86	109
[(SP6121 x 3561)3561] ms x SP5822-0	39.1	14.5	268	15.09	94.65	100
(SP6121 x 4661)ms x SP5822-0	37.6	13.8	269	15.10	94.28	100
648H2 x SP5822-0	39.7	14.4	269	15.23	94.42	93
SP6322-0	38.0	13.6	274	15.25	94.38	98
General Mean	39.6	14.3	272	15.24	94.62	101
S.E. Var. Mean	1.47	.35	5.9	.192	.321	4.1
Above as % Gen. Mean	3.71	2.44	2.17	1.26	.34	4.08
LSD 5% Point	NS	NS	NS	NS	NS	NS

Latin Square Analysis

Variance Table

Source of Variation	Mean Squares						
	D/F	Recov. Sugar	Roots	Sugar per T.	Sucrose	Purity	Beets per 100'
Between Rows	5	70.64	4.94	239	.3580	.6907	113
Between Columns	5	31.31	4.55	140	.4178	.2164	65
Between Varieties	5	17.54	1.74	90	.1265	.6378	203
Remainder (Error)	20	12.98	.73	210	.2203	.6171	102
Total	35						
Calculated F. Value		1.35	2.38	.43	.57	1.03	1.99

Standard Footnotes, a on page 293.

Section Two: Area Evaluation

Eleven of the better hybrids from the 1966 Area Evaluation trials were retested along with 25 other monogerm hybrids thought to be of value for this area. Only specific combining ability data are available from this years data. See summary table, page 303.

Complete data from an 8 replication test on the Gremel farm near Sebewaing, Michigan and sugar and purity data from a 3 replication test on the Schroeder farm near Ottawa, Ohio were available for evaluation.

The highest yielding hybrids were SP6442 and SP6423-01 pollinated by SP6322-0. Next to these hybrids the best sugar per acre performance was from (SP6121 x EL31)ms and from (SP6121 x 3561)ms polinated by SP5822-0. These hybrids were slightly better in quality than the highest yielding ones. (CT5 x SP6121)ms x SP6428-01; EL31C1 x SP6322-0; and (FC502/2 x SP581181s1)ms x SP5822-0 were also among the hybrids which produced over 6 1/2% more sugar per acre than the average.

Although hybrids involving FC502/2 appear to have above average quality (sugar/ton), seed production problems with this line should be solved before it is tested further.

PERFORMANCES IN PERCENT OF THE AVERAGE

Description			Su/A.	T./A.	Sugar/ton		% Sucrose		% Purity		<u>Beets</u> <u>100</u>
<u>CIS</u>	<u>O</u>	<u>MI</u>	Mich.	Mich.	Mich.	Ohio	Mich.	Ohio	Mich.	Ohio	Mich.
SL129 x SP6121 x SP6322-0			104.4	106.0	98.6	103.1	97.8	101.2	100.5	101.0	116.3
CT5 x SP6121 x SP6428-01			108.9	110.4	98.9	98.9	99.2	99.1	99.9	99.9	100.7
SP6121 x 648-3 x SP6322-0			87.7	90.2	97.6	97.7	97.4	97.2	100.2	100.3	109.7
SP6121 x E131 x SP5822-0			109.0	108.2	100.1	98.7	100.6	98.6	99.7	100.1	109.0
SP6121 x 3561 x SP6322-0			109.0	108.8	100.1	99.1	99.5	99.1	100.3	100.0	114.4
FC502/2 x FC505 x SP59B18-0			97.8	93.9	103.8	106.0	103.5	104.8	100.1	100.6	94.5
FC502/2 x FC505 x SP5822-0			100.5	96.3	104.4	102.5	103.5	102.0	100.4	100.2	104.0
FC502/2 x SP581181s1 x SP59B18-0			90.9	91.2	99.8	106.7	100.2	105.0	99.8	100.7	89.5
FC502/2 x SP581181s1 x SP5822-0			106.6	103.0	103.4	101.5	102.5	101.1	100.4	100.2	110.0
FC505 x SP581181s1 x SP5822-0			100.9	100.5	100.4	97.9	100.1	99.2	100.1	99.3	106.1
SP581222s1 x FC505 x SP59B18-0			78.5	73.2	100.3	94.5	101.0	96.9	99.6	98.7	72.1
SL129 x SL133 x SP6322-0			97.7	98.3	99.1	103.7	99.0	102.6	100.0	100.5	108.7
SL129 x SL133 x SP6428-01			103.5	101.7	101.3	102.9	100.8	101.2	100.5	100.9	99.6
SL133 x FC503 x SP6428-01			96.2	98.9	97.7	101.6	98.9	101.7	99.4	100.0	98.4
SL133 x EL34 x SP6428-01			102.4	103.2	99.0	94.6	99.1	96.0	99.9	99.3	96.9
SP6423-01 x SP6428-01			100.7	103.6	96.3	101.8	96.5	100.5	99.9	100.7	107.8
SP6423-01 x SP6322-0			113.8	114.7	99.5	98.2	98.8	98.6	100.4	99.9	118.2
SP6442-1 x SP6322-0			116.3	117.6	98.7	100.0	99.3	99.8	99.7	100.2	117.9
SP64209-03 x SP6322-0			101.2	104.2	97.0	96.9	97.6	97.2	99.7	99.9	105.6
SP643301-1 x SP6322-0			104.6	106.6	98.2	97.1	98.0	97.3	100.2	99.9	118.8
SP643465-1 x SP6322-0			103.1	105.1	98.2	97.7	98.6	98.1	99.8	99.8	112.8
SP65406-01 x SP6322-0			103.4	105.5	97.5	99.1	98.5	98.5	99.5	100.4	99.9
648H2 x SP6322-0			101.7	100.9	100.6	99.9	99.7	99.6	100.5	100.2	106.6
569H3 x SP6322-0			104.7	109.8	98.4	100.7	98.9	100.7	99.8	100.0	102.0
EL31C1 x SP6322-0			106.6	108.2	99.1	97.6	100.3	100.0	99.3	98.7	104.1
SP64502 x SP6322-0			89.2	87.1	101.9	101.8	101.7	101.6	100.1	99.8	88.3
FC505 x SP6322-0			103.9	100.5	103.2	104.1	102.0	103.5	100.6	100.3	96.3
FC505 x 0-2 clone			97.1	97.2	100.1	100.8	100.9	100.8	99.5	100.0	93.6
FC601 x SP6322-0			88.2	88.2	99.8	93.7	98.5	96.0	100.3	98.7	88.1
EL35C1 x SP6322-0			99.0	95.8	100.6	96.1	101.2	97.6	99.8	99.3	64.0
SP581220 x SP6322-0			96.6	96.5	99.2	102.4	99.2	101.6	100.0	100.4	89.8
SP65209 x 0-2 clone			88.3	88.6	99.4	94.5	100.1	97.4	99.7	98.5	75.3
FC503 x FC502/2 x SP6322-0			96.7	95.1	101.4		100.9		100.3		91.9
FC503 x FC502/2 x 0-2 clone			89.3	84.7	105.6	102.6	105.9	102.6	99.7	100.0	83.4
FC504 x FC502/2 x SP6322-0			100.7	99.3	101.5	104.4	100.3	102.6	100.7	100.9	102.7
FC504 x FC502/2 x SP59B18-0			101.4	102.2	99.2	101.0	99.9	100.3	99.7	100.3	102.4
LSD _{5%}			13.03	12.44	4.8		3.93		0.78	NS	14.2

Cooperator: Northern Ohio Sugar Company by Phil Brimhall, H. L. Bush,
R. K. Oldemeyer

Location: Glenn Miller Farm, Green Springs, Ohio

Year: 1967

(Results given as 8 plot averages in % of SP5822-0)^(e)

Strain	Recoverable ^(c)		Sugar Content	Thin Juice	Leaf ^(a) Spot	Beets ^(b) per 100 ft.
	Sugar Yield	Root Yield		App. Purity		
SP6622 x 027	109.01	111.61	98.38	100.30	5.4	106
SP6622 x 035	112.21	109.51	101.70	100.96	2.6	116
SP6622 x 036	105.53	106.39	100.28	99.75	2.0	122
SP6622 x 037	110.18	113.20	98.30	100.03	4.8	124
SP6622 x 038	121.99 ⁺	124.95 ⁺	98.46	99.98	3.1	118
SP6622 x 039	114.39	120.62 ⁺	96.30 ⁻	99.72	4.1	109
SP6622 x 040	108.55	111.40	96.92	100.96	3.1	124
SP6622 x 042	108.57	109.61	99.46	100.10	3.4	109
SP6528 x 027	97.32	100.19 ⁺	97.53	100.60	5.4	100
SP653170 x 027	119.79 ⁺	125.87 ⁺	96.49 ⁻	99.98	2.4	105
66H22 x 15	129.51 ⁺	127.55 ⁺	103.16 ⁺	99.66	5.1	115
66H22 x 23	98.48	95.10	103.24 ⁺	100.56 ⁺	2.8	119
66H22 x 51	98.09	94.05 ⁺	102.93	101.43 ⁺	2.4	104
66H22 x 52	120.65 ⁺	120.76 ⁺	99.38	100.84	2.0	116
66H22 x 3	112.01	114.26	101.07	99.08	5.4	115
SP66289-01	111.48	113.52	97.90	100.75	3.9	109
CV (%)	16.82	15.86	3.26	1.33	-	-
Sm/Gen.Mean (%)	5.95	5.61	1.15	0.47	-	-
LSD 5% pt. (% of SP5822-0)	18.30	17.43	3.22	1.32	-	-

Variance Table

Source of Variation	DF	Mean Squares			
		Recoverable ^(d) Sugar (lbs.)	Roots ^(d) (lbs.)	Sucrose (%)	Purity (%)
Replicates	7	1.4197	51.0114	.5363	2.5784
Varieties	17	2.5172	139.4076	1.0681	2.5764
Error	118	1.2876	50.4488	.2779	1.6671
Total	142	1.4542	61.2791	.3876	1.8326

(a) 0 = No leaf spot, 10 = complete necrosis due to leaf spot

(b) Harvest stand

(c) Calculated by electronic computer from formula used since 1953

(d) Pounds per plot

(e) Mean for SP5822-0 = 5503 lbs. recov. sugar per A., 18.08 T roots per A.,
16.21% sugar, 96.94% purity, Leaf Spot = 2.3

+ Significantly above SP5822-0 at 5% pt.

- Significantly below SP5822-0 at 5% pt.

Cooperator: Northern Ohio Sugar Company by Phil Brimhall, H. L. Bush,
R. K. Oldemeyer

Location: Ralph Heineman Farm, Lindsey, Ohio

Year: 1967

(Results given as 8 plot averages in % of SP5822-0)^(e)

Strain	(c)		Sugar Content	Thin	Leaf ^(a) Spot	Beets ^(b) per 100 ft.
	Recoverable Sugar Yield	Root Yield		Juice App. Purity		
SP6622 x 027	117.30 ⁺	123.71 ⁺	98.10	98.30 ⁻	6.1	110
SP6622 x 035	98.54	98.33	101.27	99.08	3.8	106
SP6622 x 036	94.78	96.74	98.81	99.50	1.8	107
SP6622 x 037	102.95	108.84	97.86	98.02 ⁻	5.0	106
SP6622 x 038	115.83	121.72 ⁺	98.34	98.33 ⁻	3.4	122
SP6622 x 039	112.38	113.90 ⁺	99.05	99.94 ⁻	4.0	108
SP6622 x 040	129.33 ⁺	136.77 ⁺	97.94	97.97 ⁻	2.4	125
SP6622 x 042	112.85	116.04	97.47	99.80	3.8	106
SP6528 x 027	113.49	114.70 ⁺	99.68	99.55	4.9	101
SP653170 x 027	111.46	116.73 ⁺	97.86	98.53	3.1	106
66H22 x 15	109.24	110.33	101.03	98.62	6.1	108
66H22 x 23	110.11	111.90	100.24	99.07	1.6	108
66H22 x 51	97.14 ⁺	95.90 ⁺	103.09 ⁺	99.01	2.8	100
66H22 x 52	117.29 ⁺	121.91 ⁺	99.13	98.46 ⁻	1.3	103
66H21 x 57	112.31	111.91	102.93	98.35 ⁻	6.3	100
SP66289-01	98.29	106.42	95.25 ⁻	98.14 ⁻	3.8	97
CV (%)	15.76	15.12	3.08	1.62	-	-
Sm/Gen. M (%)	5.57	5.34	1.09	0.57	-	-
LSD 5% pt. (% of SP5822-0)	16.84	16.60	3.03	1.59	-	-

Variance Table

Source of Variation	DF	Mean Squares			
		Recoverable ^(d) Sugar (lbs.)	Roots ^(d) (lbs.)	Sucrose (%)	Purity (%)
Replicates	7	2.5034	92.8587	1.3837	1.8364
Varieties	17	1.8723	113.6086	.7582	3.3774
Error	118	.6597	29.9004	.2329	2.4247
Total	142	.8957	43.0254	.3525	2.5097

(a) 0 = No leaf spot, 10 = complete necrosis due to leaf spot

(b) Harvest stand

(c) Calculated by electronic computer from formula used since 1953

(d) Pounds per plot

(e) Mean for SP5822-0 = 4273 lbs. recov. sugar per A., 14.62 T roots per A.,
15.79% sugar, 96.91% purity, Leaf Spot = 2.9

+ Significantly above SP5822-0 at 5% pt.

- Significantly below SP5822-0 at 5% pt.

PHYSIOLOGICAL INVESTIGATIONS - 1967 1/

F. W. Snyder

Germination Studies

I. Pre-germination treatments:

From a study of the effect of eight pre-germination treatments on germination performance, involving five seedlots of three varieties of sugarbeets, the following salient points are re-emphasized: 1) Seedlots of the same variety do not respond in the same manner to a given pre-treatment. 2) Maximum germination percentages can only be attained by a combination of pre-treatments. 3) Maximum germination percentages were obtained only when the fruits were hand-processed and then subjected to additional pre-germination treatment. 4) A given combination of pre-germination treatments, on the average, may induce maximum germination, but for any given seedlot, the combination of treatments may be inferior to some other combination of treatments^{2/}.

II. Safe drying temperatures:

Further work^{3/} on the effect of drying temperature on germination performance of sugarbeet seeds has indicated that sugarbeet fruits having 20 percent moisture can be dried at 145 F without adversely affecting germination. Fruits having 280 percent moisture can be dried at 120 F. Safe drying temperatures for intermediate moisture contents can be determined by plotting a straight line between the two extremes cited. Limited data involving fruit moisture content, various drying temperatures, and freshly harvested versus a period of refrigeration suggest there may be interactions between these three. Depending on the combination of conditions, the percentage germination may be increased markedly. Additional research is being done on this phase.

III. Diameter of seedling hypocotyl in relation to fruit and seedling emergence:

Seedlings that develop from seeds in large fruits have distinctly larger diameter hypocotyls than seedlings that develop from seeds in

1/ Research conducted in cooperation with Michigan Agricultural Experiment Station.

2/ Christina Filban, Laboratory Technician assisted in this research.

3/ Richard J. Patterson, Research Assistant, Department of Agricultural Engineering, Michigan State University assisted in this research.

small fruits (Table 1).

In the field, industry personnel have observed that the seedlings from small fruits do not emerge as well as seedlings from large fruits. Planting fruits in moist quartz sand at a depth of two inches has confirmed that less seedlings emerge from small fruits than from large fruits. However, the two size classes often have about the same percentage germination on blotters. Usually, the seeds in the smaller fruits germinate more rapidly on blotters (double thickness with no covering) than seeds in large fruits. Hypocotyls of seedlings germinated on blotters develop more slowly than those of seedlings germinated in sand. In contrast, when fruits are planted at a 1/2-inch depth in quartz sand, seedlings from large fruits frequently emerge more rapidly than seedlings from small fruits. In one test, fruits (pre-soaked for 20-30 minutes and kept moist) were planted at the same time that they were placed on the blotter. After four days, 80 percent of the seeds on the blotter had germinated; the longest root was seven mm long and no hypocotyls exceeded two mm. Of those planted at a 1/2-inch depth in sand, 52 percent of the seedlings had sufficiently elongated hypocotyls to emerge through the sand.

IV. Influence of distance from pollinator on seed-set on cytoplasmic male sterile sugarbeets

Percentages of seed-set on comparable branches of CMS plants located 2, 4, 8, and 16 feet from the pollen source were 65.5, 66.8, 65.8 and 61.3, respectively. The data do not fit theory very well, but can be accounted for logically. The female is receptive for a number of days. During each day, pollen is released repeatedly. Thus, for distances up to 16 feet from the pollen source, there is nearly the same statistical chance of pollination and subsequent seed-set. The relatively low average seed-set and the tendency of the actual data toward lower seed-set at 16 feet emphasize the need for high pollen density for satisfactory seed production.

Trapping pollen on microscope slides covered with vaseline, revealed that sugarbeet pollen grains often disseminate in aggregates. Less uniform distribution of this type might contribute to lowered seed-set.

Table 1. Relation of diameter of seedling hypocotyl to fruit size in hybrid monogerm sugarbeet.

Seedlot	Fruit size in in./64		Avg. wt. of 1 cm of hypocotyl Mg	Small Large Ratio
	Whole	Processed		
-	On 12	-	4.6	
	8 $\frac{1}{2}$ -9 $\frac{1}{2}$	-	4.1	0.89

6369	On 13	-	4.5	
	8-9	-	3.1	0.69

6452	On 12	-	4.3	
	8-9	-	3.6	0.84

4504	On 12	On 9	4.1	
	10-11	8 $\frac{1}{2}$ -10 $\frac{1}{2}$	3.7	0.90
	7 $\frac{1}{2}$ -8 $\frac{1}{2}$	6 $\frac{1}{2}$ -8	3.0	0.73

SUGARBEET DISEASE INVESTIGATIONS - EAST LANSING, 1967

By

C. L. Schneider, D. L. Yoder, C. G. Filban and P. Y. Ang

Greenhouse screening tests of black root resistance.

The degree of resistance of 179 seed lots from 9 East Lansing breeding lines to the fungus, Aphanomyces cochlioides was determined in a series of greenhouse inoculation tests. The moderately-resistant variety, US 401, was included in each test as a standard of comparison. Each entry was represented by five 4-inch pots of steamed soil each containing ten seedlings.

Production of zoospore inoculum was in accordance with previously-described methods (4). Inasmuch as local tap water proved to be unsatisfactory for zoospore production, mycelial mats were immersed instead in a solution of 5×10^{-4} M. $\text{Ca}(\text{NO}_3)_2$ + 10^{-4} M. KH_2PO_4 + 10^{-4} M. Mg SO_4 . The above solution was superior to tap, deionized or distilled water for zoospore production. Ten days after planting, approximately one million zoospores in 25ml water were poured into each pot of seedlings.

Plants were rated according to disease severity about 30 days after inoculation and an average severity rating for each line was computed. Most lines were more resistant than check variety, US 401 (Table 1). An interesting and unexpected finding in these tests was that the progenies from Botrytis cinerea storage rot resistant selections were considerably more resistant to Aphanomyces cochlioides infection than were Botrytis-susceptible selections out of the same line. Further studies should reveal whether resistance to both diseases is truly related or not.

Selection for Aphanomyces resistance in the greenhouse.

A program of selecting Aphanomyces-resistant plants in the greenhouse for use in the breeding program was begun in 1967. Seedlings, from seed germinated in vermiculite were inoculated with the pathogen in accordance with a method described by MacWithey (2). Seedlings were removed from vermiculite about 10 days after planting, and were placed in petri dishes each containing approximately 500,000 zoospores in 20ml water. Roots and lower portions of the hypocotyls were immersed in the inoculum for 7-16 hours then the seedlings were transplanted to 4" pots of steamed soil - 4 plants per pot.

In a series of tests, 26 East Lansing breeding lines were inoculated. Included were 11 monogerm and 15 multigerm lines. In most cases at least 100 plants of each line were tested. In each test for comparison,

there was included a representative number of plants of variety US 401. About 60 days after inoculation, plants were graded numerically according to disease severity from 0 (no above ground symptoms) to 5 (plant dead).

In most every line tested the plants differed widely in severity of symptoms. The average severity ratings of the 26 lines ranged from 68% to 151% of check variety, US 401. Disease severity in US 401 varied considerably from test to test, most likely in response to differences in greenhouse temperatures prevailing at different times during the testing period from June through December.

Plants that received severity ratings of 0 or 1 in lines that showed average severity ratings superior to the check variety were selected as possible sources of black root resistance in the breeding program. Groups of selected plants have been planted in ground beds in the greenhouse for seed production. Subsequent greenhouse inoculation tests of the resistance of the progeny and parental lines should indicate the degree of progress in increasing black root resistance that can be expected by this method of testing and selection.

Studies on *Aphanomyces cochlioides* oospores.

Methods of producing mass quantities of *Aphanomyces cochlioides* oospores in vitro were investigated. The fungus produced abundant oospores in decoctions of leaves, seeds and roots of various plants including the following: maize kernels, sugarbeet leaves, sugarbeet roots, dried peas, sorghum kernels, V-8 broth, tomato seedlings, shepherds purse leaves, carrots and maize meal. No oospores were produced by the fungus in decoctions of raisins, lentils, soybeans or sweet lavender seedlings nor in extracts of malt, yeast or beef.

Nutrient concentrations optimum for oospore production in liquid media were about one-half or less of concentrations optimum for vegetative growth. A combination of abundant vegetative growth and oospore production was obtained by growing the fungus in liquid media at nutrient concentrations optimum for vegetative growth then transferring the mycelial mats after about 5 days growth to a solution of 5×10^{-4} M. $\text{Ca}(\text{NO}_3)_2$ + 10^{-4} M. MgSO_4 + 10^{-4} M. KH_2PO_4 . Shortly thereafter oospores were produced in the mats at densities about equal to those produced in sparser media. Comparatively few oospores were produced when mycelial mats were transferred from liquid media to distilled water.

On solid media, such as nutrient agar, oospores were produced at nutrient concentrations higher than when liquid media were employed. Abundant oospores were also readily produced when the fungus was grown on particulate media, such as 2 parts vermiculite or perlite and 1 part nutrient broth. Because of advantages offered by a particulate medium, such as large amount of surface area for inoculum growth and ease in distribution, further studies on mass production of oospore inoculum were confined to this type of medium.

Optimum pH for oospore production in vitro was between 6.25 and 6.50.

Germination and infectivity of oospores was studied. The fungus was grown for about one month in liquid media that favor oospore production, such as beet leaf decoction (25g/l.) and maize kernel decoction (40g/l.). Mycelial mats, rich in oospores, were then removed from flasks, rinsed in sterile water and thoroughly dried on 5cm squares of cellophane or plastic screen. Oospores, largely free of mycelium, were obtained by homogenizing mycelial mats in a Waring blender with about 30ml water for 5 minutes then transferring drops of the resulting oospore suspension on microscope cover glasses to dry. Various substrates were applied to the dried oospores in moist chambers.

In the following substrates, oospores were observed germinating: sugar-beet soil leachate, sugarbeet seedling decoction, a 4-salt solution and casein hydrolysate (300 and 600 mg/l.). Percentage of spores germinating at a given time was extremely low - less than 1 per 1000. Germ tubes in some instances were branched and attained lengths of about 100-150 μ . Although none were seen to function as zoosporangia, zoospores, in some instances were observed swimming in substrates in which oospores germinated.

No oospores were observed to germinate in the following substrates: coconut milk, naphthalene acetic acid, indole acetic acid and distilled water. Exposure to temperatures ranging from 0 - 50°C or to alternate freezing and thawing did not appear to increase oospore germination.

Infectivity of oospores was studied in the greenhouse. When oospores were added to steamed soil when seed was planted, emerged seedlings developed typical symptoms of Aphanomyces seedling blight. Density of oospores influenced incidence of seedling infection (Table 3). No infection ensued when dried mycelial mats lacking oospores were added to the soil. Dried mycelial mats or vermiculite cultures containing oospores were infectious at least one year after they were produced in vitro and dried.

The use of oospore inoculum for inducing infection in greenhouse and field tests of resistance of sugarbeets is currently being investigated. Two kinds of vermiculite media are being used because they provide a high level of vegetative growth and oospore production and because they are infectious for prolonged periods after drying. In one kind the nutrient consists of maize meal (25 gm per liter of water) and in the other a semisynthetic medium described by Mehrlich (3) is used.

Tests with a new systemic fungicide.

A field test was conducted to determine the efficacy of soil applications of DuPont experimental fungicide 1991 in controlling leaf spot (Cercospora beticola). Systemic control of the disease in the greenhouse through soil application as well as direct control in the field by foliar application has been reported (1). In our test, we applied

the chemical in aqueous suspension along the plant rows at varying rates on two different dates. A highly susceptible variety (Synthetic #2) and a moderately resistant variety (US 401) were represented.

In early June, plots were artificially infested with *C. beticola* inoculum consisting of ground sugarbeet leaves infected with fungus the previous year. Inoculum was applied with an air-blast type knapsack crop duster.

In September and October, the effect of the chemical in reducing leaf blight was noticeable, indicating systemic action through soil application of the fungicide (Table 5). Further studies in regard to dosage and time of application are planned in order to determine the practicality of attempting systemic control inasmuch as a high level of control through conventional foliar application can also be expected on the basis of previous reports published by the manufacturer.

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Table 1. *Aphanomyces* susceptibility ratings of sugarbeet^{1/} lines tested in the greenhouse at East Lansing, Mich. in 1967.

Sugarbeet Line	Type	No. entries in each susceptibility class ^{1/}				No. entries tested	Av ^{1/} rating
		50-69	70-89	90-109	110-129		
66B4-	MM sel BR Nursery	12	7	1	0	20	69.85
66B5-	MM sel in LS Nursery	0	1	3	0	4	96.00
66B6-	Progeny of line seg for mm	2	3	0	0	5	74.50
66B8-	mm LS sel	0	3	1	0	4	82.25
66B11-	O-type MM	2	1	0	0	3	64.00
66B12-	Red	1	2	0	0	3	76.33
66B13-	Botrytis stor. rot res. sel. from SP6322-0	4	28	28	4	64	88.90
66B14-	Botrytis suscep. sel. from SP6322-0	0	1	4	4	9	106.22
66B15-	Tetraploid 0-2 Clone	13	42	11	1	67	78.67

^{1/} Susceptibility ratings expressed in percent of check variety, US 401. The higher the rating, the greater the degree of susceptibility.

Table 2. Segregation of seedling progeny from selfed seeds according to susceptibility to Aphanomyces cochlioides in greenhouse tests at East Lansing, Michigan in 1967: No. plants in each susceptibility class.

Sugarbeet Line	Susceptibility classes ^{1/}						Total Plants	Av. disease Rating	
	0	1	2	3	4	5		In %	
								US	401
I Monogerm 0-type:									
66B1s1	0	4	10	60	26	0	100	3.1	92
s2	0	1	5	31	40	30	107	3.9	145
s3	0	3	10	61	22	2	98	3.1	124
s4	0	4	27	60	8	1	100	2.8	117
s5	0	6	42	126	24	2	200	2.9	118
s6	0	6	23	50	20	1	100	2.9	151
s7	0	4	28	32	4	0	68	2.5	95
s8	1	4	11	36	27	1	80	3.1	116
Line av.								3.04	107.2
66B2s4	0	8	31	42	15	0	96	2.7	121
s5	0	0	0	2	0	28	30	4.9	123
s6	0	1	1	1	5	17	25	4.4	112
Line av.								4.00	118.0
II Multigerm 0-type:									
66B3s2	0	0	8	9	3	55	75	4.4	98
s6	0	4	11	22	8	55	100	4.0	89
s8	0	0	6	19	49	31	105	4.0	98
s12	0	1	15	23	56	15	110	3.8	93
s28	0	11	26	53	9	11	110	2.9	84
s29	0	2	23	56	23	6	110	3.1	90
s31	0	11	32	49	18	10	120	2.9	79
s32	0	2	15	78	25	0	120	3.1	84
s40	0	16	37	48	16	3	120	2.6	115
s45	0	7	33	46	13	6	105	2.8	122
s46	0	6	62	36	8	8	120	2.6	143
s53	0	15	52	39	17	13	136	2.7	68
s63	0	7	22	36	14	9	88	3.3	120
s65	0	7	18	18	31	62	136	3.9	97
s67	0	2	6	20	23	39	90	4.0	103
Line av.								3.32	98.9

^{1/} Disease susceptibility ranged from 0 (no symptoms) to 5 (dead).

Table 3. Effect of density of *Aphanomyces cochlioides* oospores on incidence of sugarbeet seedling blight in pots of steamed soil.

Approximate No. of ^{1/} oospores per 4" pot	No. pots in which ^{2/} infection occurred	Incidence of infection ^{3/}
0	0/3	0/47
700	0/3	0/47
1,600	0/3	0/45
3,400	0/3	0/52
6,800	1/3	12/57
13,000	2/3	34/49
26,000	3/3	37/46

^{1/} Density of oospores in dried suspensions on microscope coverslips was determined by microscopic count, then appropriate number of coverslips were added to each pot to give desired number of spores.

^{2/} No. pots with infection/Total no. of pots.

^{3/} No. plants infected/Total no. plants emerged.

Table 4. Effect of soil applications of experimental fungicide DuPont 1991 on leaf spot infection (C. beticola) in two sugarbeet varieties at East Lansing, Michigan in 1967.

Date of application and dosage (lb. of fungicide per acre) ^{1/}	Leaf spot severity ratings ^{2/} in each variety on dates indicated					
	Synthetic #2			US 401		
	24 Aug.	20 Sept.	2 Oct.	24 Aug.	20 Sept.	2 Oct.
23 May ^{3/}	0.0	5.2	5.7	2.0	3.2	3.5
	3.1	4.8	5.3	2.0	3.2	3.7
	6.2	4.8	5.2	1.7	3.0	3.5
26 July ^{4/}	0.0	5.0	5.1	2.3	3.8	4.0
	3.1	4.5	4.8	1.5	3.0	3.0
	6.2	3.3	3.6	1.5	2.8	2.8
	12.4	2.8	3.0	1.5	2.5	2.5

- ^{1/} Material applied in 1 liter of water per 20 ft. of row.
- ^{2/} Expressed according to a scale from 0 (no symptoms) to 10 (complete defoliation).
- ^{3/} Data expressed as mean of 6 single-row plots, each 20 ft. long.
- ^{4/} Data expressed as mean of 4 single-row plots, each 20 ft. long.

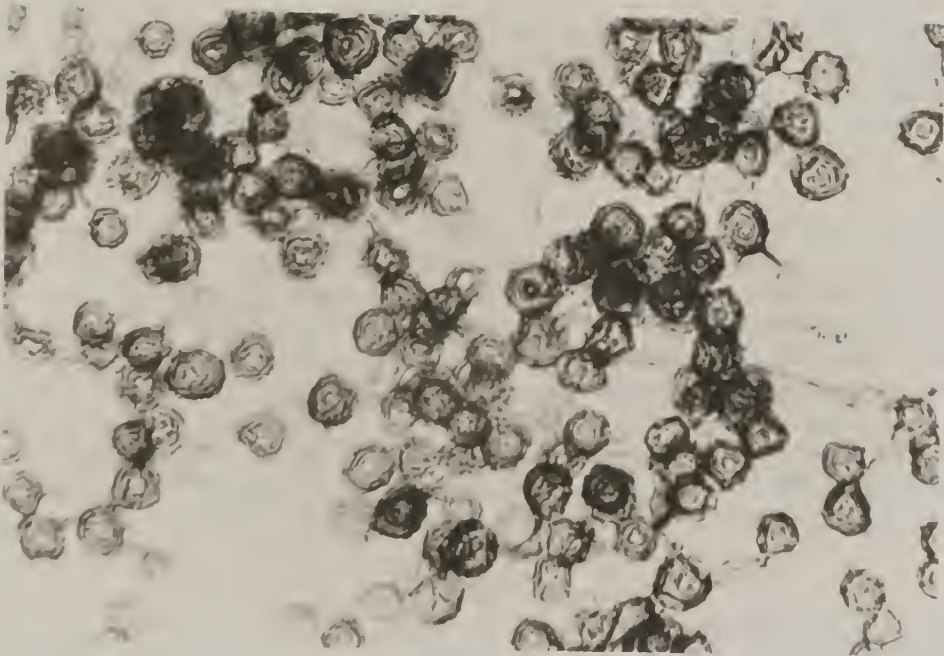


Fig. 1.--Aphanomyces cochlioides oospores in a microscopic mount of a desiccated culture, produced approximately 8 months previously in a sugarbeet leaf decoction. It is believed that the heavy walls of the oospores enable the fungus to survive in the soil during adverse environmental conditions.

Cercospora Leaf Spot Investigation ^{1/}

G. F. Stallknecht

R. Cressman

Damage to sugar beet crops in Minnesota and eastern North Dakota due to Cercospora leaf spot was light in 1967, with the exception of a small number of unsprayed fields in southern Minnesota. Activities included both field and laboratory studies on Cercospora leaf spot in 1967.

Leaf Spot Disease Survey in Minnesota and North Dakota

In 1967, we continued our studies, begun in 1965, to obtain quantitative data on the incidence and distribution of leaf spot in the sugarbeet-growing areas of Minnesota and North Dakota.

Ninety-four fields representative of the beet growing areas, were surveyed during July, August and September to obtain a picture of the dynamics of disease increase during the growing season. No disease was observed in northern Minnesota or eastern North Dakota. Absence of disease can be attributed primarily to the extremely dry growing season this year.

In southern Minnesota 16% of the fields were severely infected and 16% were slightly infected. Generally, weather conditions in the southern sugar beet regions, that is adequate rainfall and warm temperatures, were conducive to the build up of Cercospora leaf spot. Results from the leaf spot surveys in the past three years agree with such a relationship. The fields which had high disease ratings were usually not sprayed for control of Cercospora, or if sprays were applied, they were put on too late for adequate control of disease. Approximately 75-80% of the farmers in the southern Minnesota beet growing regions spray for control of Cercospora leaf spot; this accounts for those fields showing little or no disease present.

In the Red River Valley area of northern Minnesota and North Dakota, moisture and temperature fluctuation do not permit standard spray program predictions at this time. Results from survey data from 1966 show, however, that adequate moisture, combined with warm temperatures will lend to conditions which warrant spray programs, particularly in the southern portion of the valley. In 1965, there was adequate moisture in the valley beet-growing regions, but temperatures were much below normal, and Cercospora leaf spot incidence was minor.

Results from Disease Survey data from 1965-1967, show that spray programs are very important for disease control in southern Minnesota and that temperatures and rainfall greatly influence disease build up,

^{1/} In cooperation with the Department Plant Pathology and the Agricultural Experiment Station, University of Minnesota; and the Red River Valley and Southern Sugar Beet Growers Associations.

particularly in the northern beet-growing regions.

Fungicide Studies

Laboratory studies involved the assay of a Merck fungicide, Thiobendazole, (2- 4-Thiazolyl - benzimidazole).

Most fungicides used commercially for control of fungus pathogens are protectant fungicides, which arrest the pathogen prior to its entering the host plant. Few chemicals are available which will arrest the pathogen once it is established within the host plant. Research from the Merck Chemical Division indicated that Thiobendazole (TBZ) had systemic activity against Cercospora beticola Sacc. We therefore investigated the systemic activities of TBZ as a fungicide against Cercospora beticola established within the host plant, sugar beet, Beta vulgaris L..

Cercospora beticola cultures were grown as described by Stallknecht and Calpouzos (1). Three-month-old sugar beet plants were inoculated and incubated by the technique of Calpouzos and Stallknecht (2). After the plants were inoculated, the inoculum was allowed to dry on the leaves, and the plants were placed in a humidity chamber. The chamber was programmed to give a 3-minute mist period every one-half hour, to provide a relative humidity of 100%.

The plants were incubated for three days, removed from the chamber, and allowed to dry before placing them in a controlled environment chamber, programmed for a 14-hour day at 22° C. and a 10-hour night at 16° C. On the fourth day after inoculation, at which time the fungus is well established within the plant, the fungicide TBZ was applied as a soil drench in 100 ml. of water. The fungicide was applied at the rates of 2.0, 4.0 and 8.0 lb. per acre, based on a surface area deposit received on one acre and calculated for the surface area of a 6-inch pot.

Results given in Table 1 show that TBZ, when applied as a soil drench, will move through the plant and retain its activity as a potent fungicide against the established fungus in the host. This eradicant action is quite significant since no other fungicides previously investigated had activity as a chemotheropeutants.

The Merck fungicide TBZ also has demonstrated outstanding control of Cercospora leaf spot on sugar beets, (American Crystal Sugar Beet Company, unpublished data, Froyd and Johnson (3), and Froyd, Johnson and Stallknecht (4). This fungicide definitely merits further investigation in its role as a systemic chemical.

1. Stallknecht, G. F. and L. Calpouzos. 1968. Fungicidal action of triphenyl tin hydroxide toward Cercospora beticola on sugar beets. Phytopathology.
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Table I

Systemic Activity of Thiobendazole (TBZ) against

Cercospora beticola on Sugar Beet Leaves

Formulated Fungicide (lbs/acre) ¹	Actual TBZ (lbs/acre)	Average Disease rating 0-5 ²	Exp 1	Exp 2
0	0	3.7	4.0	3.3
2	1.2	1.3	0.7	1.9
4	2.4	0.6	0.1	1.0
8	4.8	0.1	0.0	0.3

1. Applied as a soil drench at a calculated rate equivalent based on surface area.
2. Disease rating 0 - no leaf spot 5 - all leaves dead, 14 days after inoculation.

DEVELOPMENT OF BREEDING MATERIAL RESISTANT TO LEAF SPOT AND BLACK ROOT

G. E. Coe

Research under Foundation Project 26 at the Plant Industry Station, Beltsville, Maryland, is directed mainly toward varietal improvement in resistance to *Cercospora* leaf spot and *Aphanomyces* black root. This program contributes to the synthesis of many varieties and hybrids evaluated in field tests reported in Part V.

This progress report covers trends in the performance of basic breeding material in leaf spot and black root resistance of some new monogerm O-type and male-sterile lines; and field performance of some experimental hybrids in the 1967 nursery tests; and the effect of relative humidity on the severity of black root epidemics in greenhouse seedling tests.

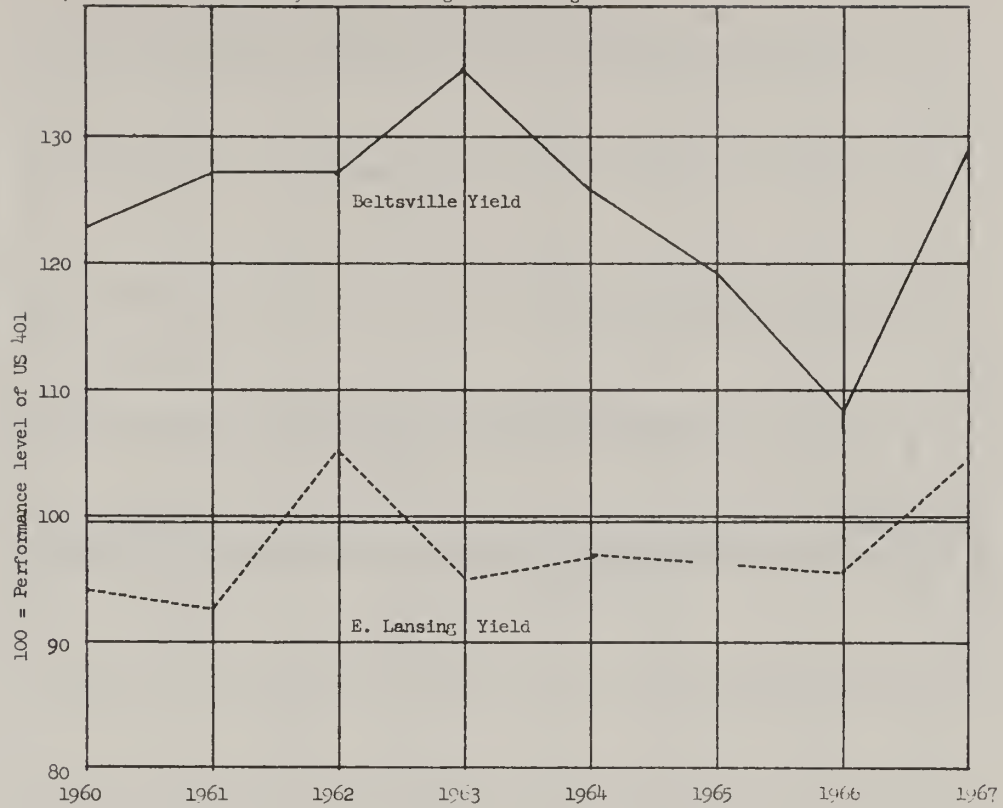
Trends in Basic Breeding Stocks

Graphs 1 through 8 show the trends in disease resistance and agronomic characteristics and compare the performance of multigerm and monogerm breeding lines with the performance of US 401. US 401 is given a numerical value of 100. The average performance of all the breeding lines is compared with that of US 401. Thus, ratings above 100 indicate that the lines as a group performed better than US 401, and ratings below 100 indicate that they did not perform as well as US 401. In percentage nonsugar solutes, ratings above 100 indicate better performance; hence, a lower percentage of soluble nonsugar constituents.

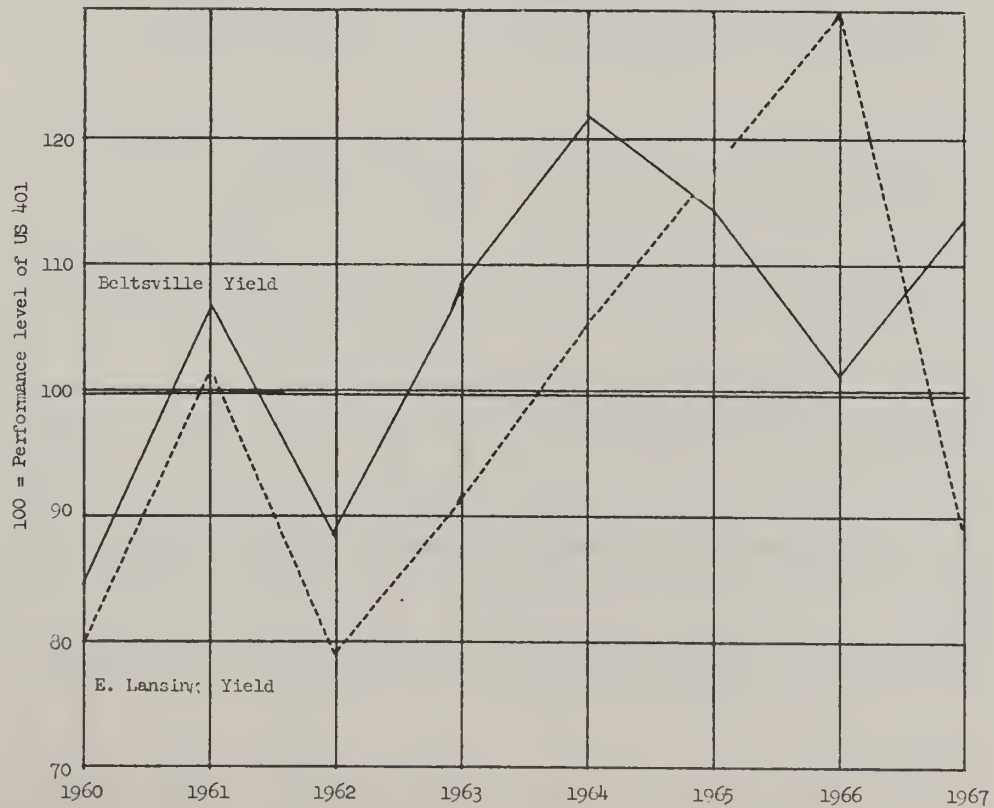
Since 1963, there has been no significant improvement in the average leaf spot resistance of either the multigerm or the monogerm lines (Graphs 1 & 2). This can be attributed to the failure of the Beltsville Nursery Test to differentiate between lines with fairly high resistance, thus rendering selection efforts rather ineffective. Different techniques must now be explored in an attempt to increase the severity of leaf spot epidemics. Increased intensity of leaf spot exposure should induce observable differences among lines and individuals of breeding material already displaying a good level of resistance.

There appears to have been no improvement of the multigerm lines in resistance to black root since 1960 (Graph 1). The monogerm lines, however, have exhibited a trend of small increments of resistance with a big increase in 1967. The increased resistance in 1967 is probably not actually as great as it appears in Graph 2, but it may very well be significant.

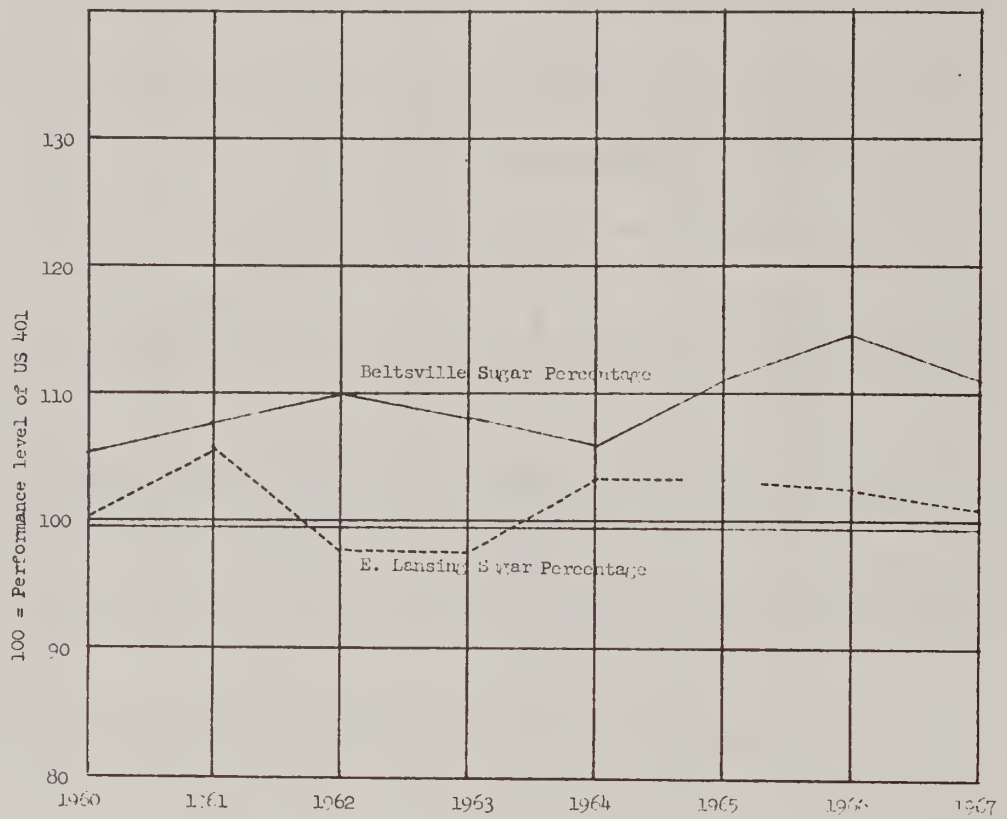
Graph 3. Trends in root yield of multigerm breeding lines.



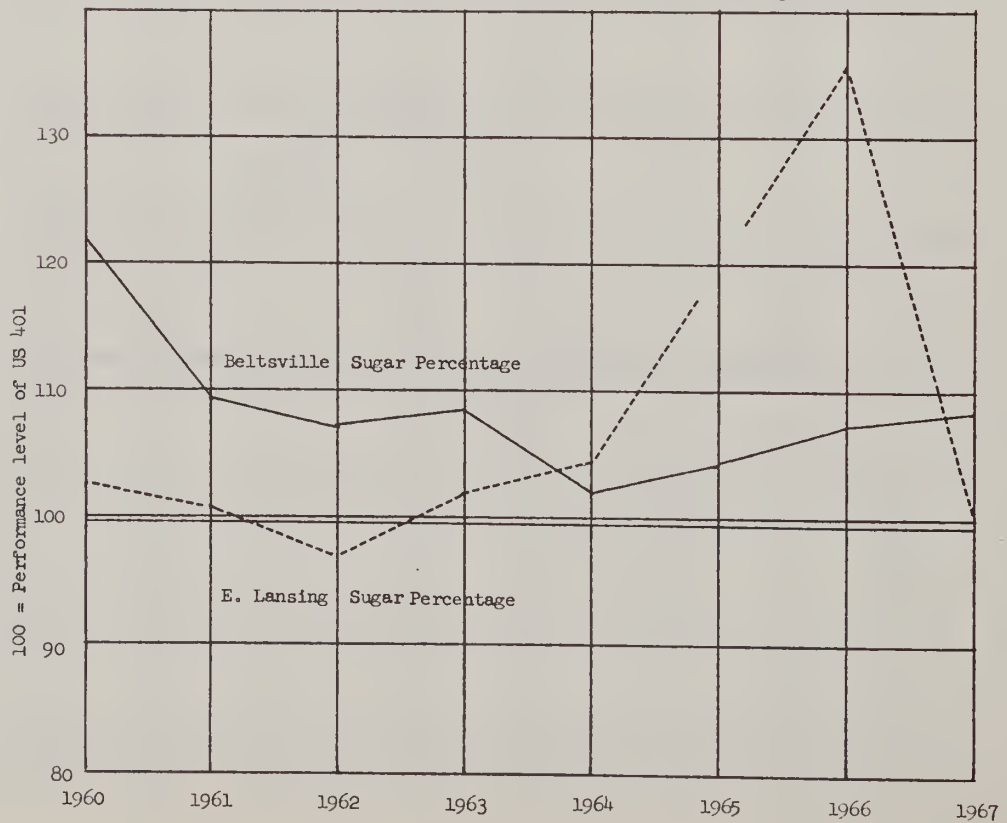
Graph 4. Trends in root yield of monogerm breeding lines.



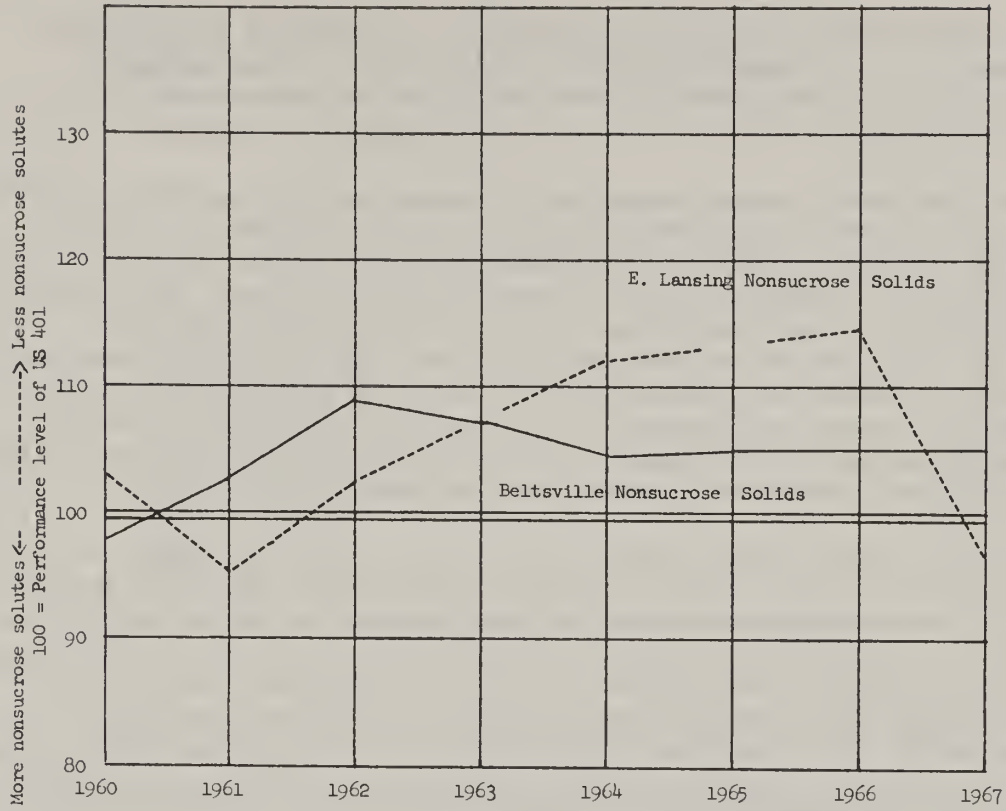
Graph 5. Trends in sucrose percentage performance of multigerm breeding lines.



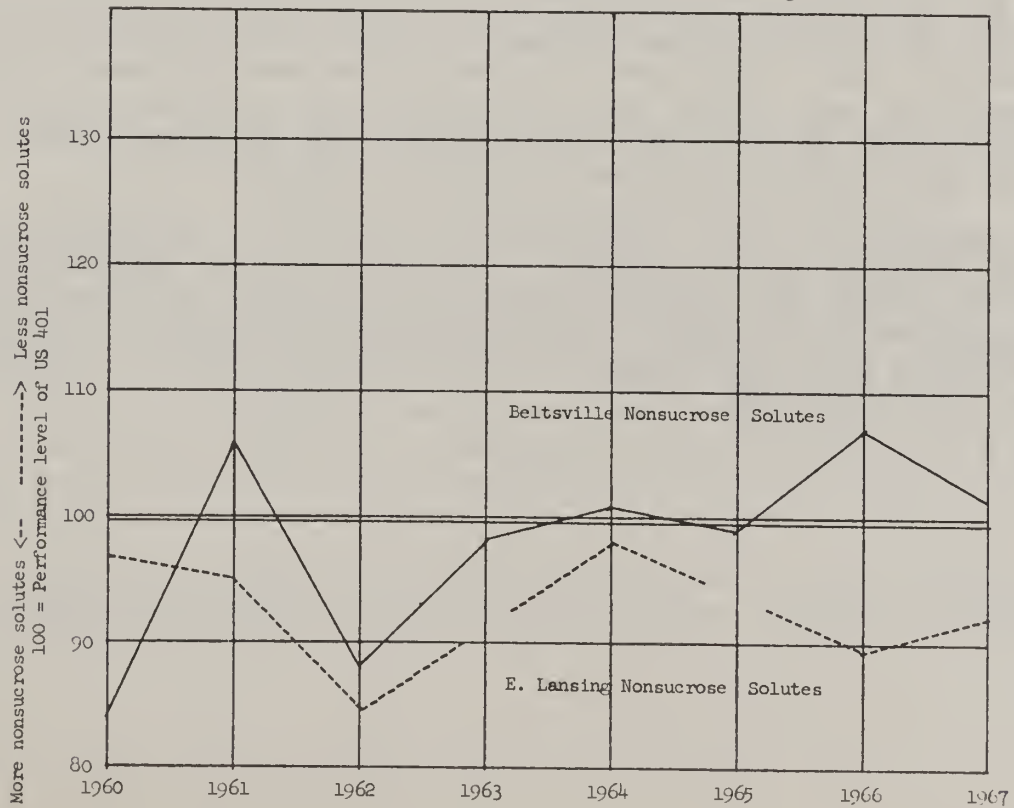
Graph 6. Trends in sucrose percentage performance of monogerm breeding lines.



Graph 7. Trends in percentage nonsucrose solutes of multigerm breeding lines.



Graph 8. Trends in percentage nonsucrose solutes of monogerm breeding lines.



The root yields of the multigerm lines have changed but little since 1960 (Graph 3). The general trend of root yields in the monogerm lines has been upward (Graph 4), but at E. Lansing they were quite low in 1967. The reason for this poor performance is unknown.

There has also been little change in the sugar percentage of the multigerm breeding lines since 1960 (Graph 5). Sugar percentages higher than US 401 at Beltsville are attributable to the better leaf spot resistance of the breeding lines. Between 1960 and about 1963, there was a decrease in sugar percentage of the monogerm breeding lines (Graph 6). This can be related to the increasing root yields during that period. Since about 1964, there appears to have been a slight improvement in sugar percentage. It is believed that this is actual improvement and not just apparent. The extremely high sugar percentage of the monogerm lines at E. Lansing in 1966 must be discounted.

The content of nonsucrose solutes in multigerm lines was higher at E. Lansing in 1967 than US 401, giving a performance rating of only 97 (Graph 7). It is hoped that this is attributable to chance and not to a regression of this characteristic. One must conclude that there has been little change in the content of soluble nonsucrose solids since 1962. One must also conclude that decrease in soluble nonsucrose solids of the monogerm lines has been very slight since 1960 (Graph 8) and that they are considerably higher in these constituents than the multigerm lines. Continued efforts must be made to improve this characteristic in the monogerm lines.

Development of BRR-LSR mm 0-type Lines

Only 5 new apparent mm 0-types were found at Beltsville in the spring of 1967. All of these were from breeding lines with some tolerance to black root and leaf spot. Selfed seed from the 0-types and their male-sterile companion lines were started in the greenhouse and transplanted to the leaf spot nursery in May. The leaf spot resistance of several lines exceeded the leaf spot resistance of SP6322-0 (Table 1).

It is interesting that every male-sterile line had less resistance to leaf spot than its companion 0-type. This is because the male-sterile plant used in each test-cross was from a line with less resistance than the presumptive 0-type monogerm plant with which it was mated. A few generations of backcrossing should result in improved leaf spot resistance in the male-sterile line.

Table 1. Leaf spot ratings of new monogerm O-types and their male-sterile companion lines in the 1967 Beltsville nursery.

Variety No.	Anther type	Leaf Spot Rating*
6322-0	Pollen Fertile (Multigerm check variety)	2.50
66221.	" "	1.50
66221-1	Male-Sterile	2.25
66235.	Pollen Fertile	1.00
66235-1	Male-Sterile	2.00
66247.	Pollen Fertile	2.00
66247-1	Male-Sterile	2.75
66333.	Pollen Fertile	2.50
66333-1	Male-Sterile	3.00
66337.	Pollen Fertile	1.75
66337-1	Male-Sterile	2.25

*Leaf Spot Ratings; 0 = No leaf spot; 10 = all leaves dead due to leaf spot.

Nursery Test Results of Experimental Single-cross Hybrids

Male-sterile companion lines of monogerm O-types indexed in the spring of 1966 were crossed to SP6322-0 MM PF in the greenhouse in late winter of 1967, and seed was available for an April nursery planting. Fifteen 1967 experimental black root and leaf spot resistant hybrids and ten 1966 experimental hybrids were evaluated in a triple-lattice replicated test in 1967 at Beltsville and E. Lansing. The plots were single rows 20 ft. long with 2 ft. between the rows. The results of the Beltsville test are presented in Table 2.

Hybrids having FC901 as the pollinator did not perform well in these two nurseries. Several hybrids having SP6322-0 as the pollinator did reasonably well. The monogerm male-sterile parents of these good hybrids are the objects of interest. SP64209-03 mm MS appears to be a good parent, but the O-type SP64209-0 is a sparse pollen producer, and seed production is quite low. Similar difficulty is being encountered with SP6468-1 mm MS. SP6442-1 mm MS has an O-type maintainer with seed stalks only about 2 ft. in height; thus seed production by this line is rather poor. SP65599-2 mm MS also has an O-type maintainer which is somewhat lacking in vigor. The O-type maintainer of SP65550-1 mm MS is better in vigor, but is not as vigorous as might be desirable. The hybrid SP65503-1 mm MS X SP6322-0 MM PF does not have as much leaf spot resistance as desirable; otherwise it performed well.

More information is needed on the other monogerm male-sterile, (SP643301-01), whose hybrid offspring did well in the 1967 nursery. However, it presently appears to be promising.

Table 2. Leaf spot and harvest data of experimental hybrids in 1967 Beltsville nursery tests.

Variety	Performance in % of General Mean				Actual Leaf Spot Rating		
	Gross Sugar	Root Yield	% Sucrose	Raw Juice Apparent Purity			
SP6423-01	X	SP6322-0	91.0	88.5	99.8	101.7	3.7
SP64217-01	X	"	76.1	81.3	106.7	102.2	3.0
SP64218-01	X	"	121.8	105.5	113.3	101.4	3.3
SP64209-03	X	"	124.2	126.4	94.5	97.9	3.3
SP65406-01	X	"	119.2	114.8	101.6	100.4	3.3
SP643301-01	X	"	118.8	119.3	97.8	99.7	3.7
SP643448-2	X	"	90.6	97.5	90.7	99.6	3.7
SP643465-1	X	"	87.6	91.9	92.5	97.8	4.0
SP6442-1	X	"	106.5	114.0	91.3	99.1	4.3
SL (129 X 133)	X	"	77.1	90.6	98.9	100.1	3.7
SP6468-1	X	"	114.4	115.7	95.8	100.2	4.0
mm MS Pool	X	Selected MM	111.2	112.3	96.6	96.9	4.0
mm MS Pool	X	" mm	111.8	113.3	96.3	96.7	3.3
FC(503 X 502/2)	X	FC901	101.3	94.6	103.7	100.8	5.0
(581194s1 X FC 502/2)	X	"	78.2	74.2	103.7	100.6	4.3
FC(504 X 502/2)	X	"	42.4	46.5	98.6	102.2	4.0
(FC502/2 X 622071s1)	X	"	69.4	65.5	103.4	102.4	4.7
SP6423-01	X	"	63.0	68.4	90.0	99.5	5.0
SP65209-03	X	"	41.7	42.7	95.3	100.4	4.7
SP65406-01	X	"	65.4	67.8	94.0	98.7	5.0
SP65515-1	X	SP6322-0	140.7	126.8	108.2	100.3	3.3
SP65503-1	X	"	120.9	127.8	103.4	100.2	4.0
SP65505-1	X	"	123.2	122.3	98.1	97.8	3.3
SP65519-1	X	"	114.7	122.0	105.4	99.5	3.0
SP65529-1	X	"	91.5	92.9	102.7	101.0	3.3
SP65530-1	X	"	84.5	96.4	104.4	100.1	3.7
SP65547-1	X	"	117.4	108.8	105.2	101.6	3.7
SP65550-1	X	"	119.0	111.4	104.2	101.1	3.0
SP65552-1	X	"	122.3	117.0	101.9	99.3	3.0
US401			83.2	90.4	89.7	97.3	5.0
SP65555-1		"	111.1	105.5	102.7	99.6	3.3
SP65559-1		"	98.2	104.5	103.1	100.4	3.0
SP65599-2		"	123.4	117.6	102.4	99.4	3.0
SP65621-1		"	104.7	95.4	106.9	99.6	3.7
SP653351-1		"	106.9	105.2	98.9	100.0	3.3
SP653365-1		"	126.5	125.5	98.3	102.1	4.0
General Mean (Actual)			4110	15.63	13.15	83.39	3.77
LSD (.05)			41.5	38.3	9.1	2.6	.90
Coefficient of variation			20.6	19.0	4.6	1.3	11.5

Effect of Relative Humidity on the Severity of Black Root Epidemics in Greenhouse Tests

Difficulty has been experienced in obtaining black root epidemics of sufficient severity in the greenhouse screening tests. It was noted that considerable variation in the severity of the epidemic occurred in tests planted at weekly intervals even though conditions were kept as uniform as possible. The conditions which we attempted to control included dosage of inoculum, greenhouse temperatures, and soil moisture. The effect of temperatures and soil moisture in this test had previously been demonstrated by C. W. Schneider. However, some other factor appeared to be even more important than these two, and the mildness of the epidemics was making it quite difficult to differentiate between the more resistant lines of sugarbeets. For a time, it was believed that some condition of the zoospores was rendering them impotent and resulting in light infections and "escaped" seedlings. However, other observations led to testing in chambers where light, temperature, and humidity could be controlled. Two chambers were used. Light and temperature settings were identical; but the relative humidity of one was set at 30%, and the other was set at 100%. The test saucers in the 30% relative humidity chamber were placed in large petri dishes filled with water to help maintain a high soil moisture content. Figure 1 shows the difference in severity of black root 5 days after inoculation. High relative humidity appears to be the main factor in obtaining severe black root epidemics. This was further tested by placing high capacity humidifiers in greenhouse units where screening tests were being conducted. Increased black root severity was soon apparent in all tests. However, some complications of humidifying entire greenhouse units were readily observed. Mechanical problems must be solved to obtain uniform humidity conditions within each separate experiment. The duration of high humidity conditions can be used to help control the severity of the epidemic. Humidity control will probably become the prime factor in the efficiency of screening and selecting for further improvement in black root resistance.

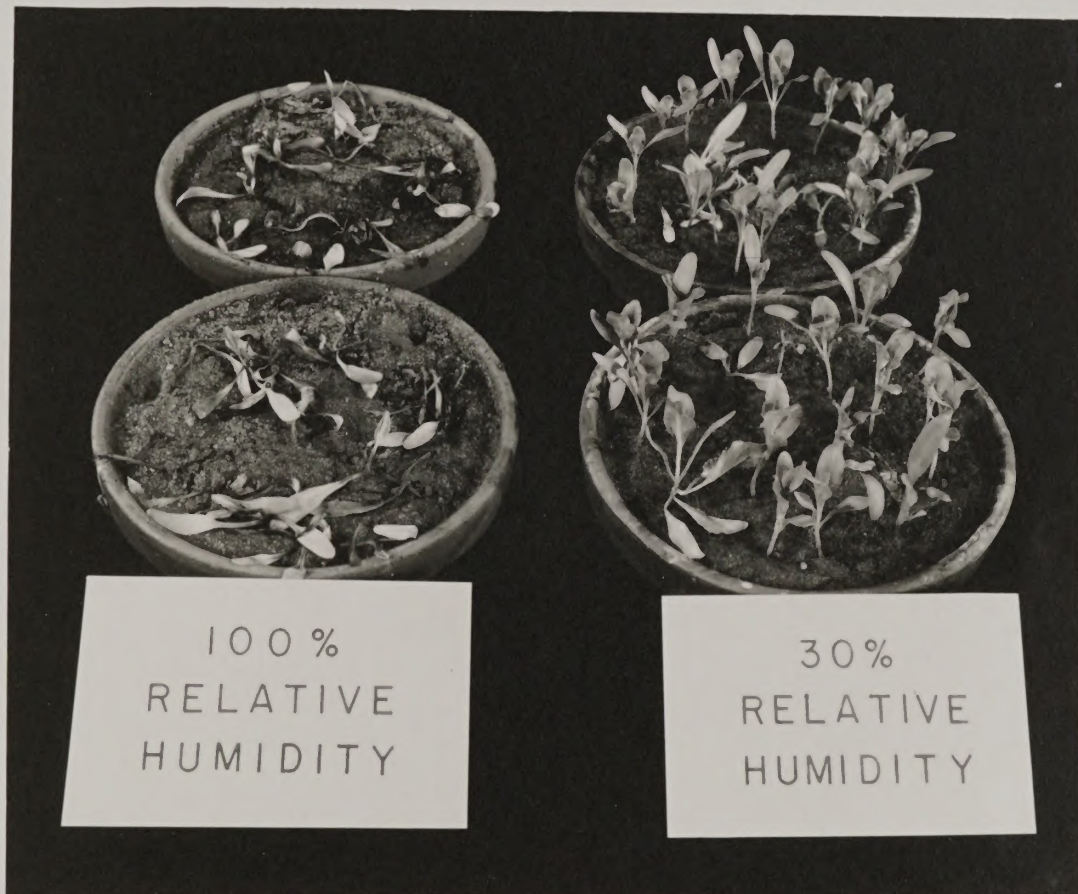


Fig. 1.--Sugarbeet seedlings 5 days after inoculation with Aphanomyces cochlioides in controlled environment

